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Regulatory Impact Analysis of the National Ambient Air Quality Standards for Carbon Monoxide

Energy and Environmental Analysis, Inc.
Arlington, VA

Prepared for

Environmental Protection Agency
Research Triangle Park, NC

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REGULATORY IMPACT ANALYSIS OF THE NATIONAL AMBIENT AIR QUALITY STANDARDS FOR CARBON MONOXIDE

Prepared for:

Office of Air Quality Planning and Standards
Environmental Protection Agency
Durham, North Carolina

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16. ABSTRACT

This report presents economic impact information for alternative eight-hour carbon monoxide national ambient air quality standards. The alternatives are 7 ppm, 9 ppm, and 12 ppm (on a daily maximum basis, where the highest eight-hour average for a day is used to determine if the expected number of exceedances of the standard is less than or equal to one per year).

Annualized 1987 societal costs of controlling carbon monoxide emissions for the three alternative standards are $2.9, $2.85, and $2.61 billion, respectively. An Urban and Community Impact standard is included as part of the report. It shows that there are no significant income distribution impacts associated with any of the alternative CO standards.

Cost and economic impacts of CO emission controls on selected industries were investigated. The analyses included capital and annualized control costs, availability of financial capital for control requirements, and potential product price and output impacts. Generally, the impact of any of the alternative standards on these items was minor.

This report is intended to meet the requirements of a regulatory impact analyses. (See Executive Order 12044 and 44 Federal Register 30988 (May 29, 1979).)

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Regulatory Impact Analysis Economic Impacts / Economics Cost Impacts / Costs Air Pollution Control Costs Urban and Community Impact Analysis		EPA 68A

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PREFACE

In accordance with the provisions of Sections 108 and 109 of the Clean Air Act as amended, the Environmental Protection Agency has conducted a review of the criteria upon which the existing primary and secondary carbon monoxide standards are based. The Act specifically requires that National Ambient Air Quality Standards be based solely on scientific criteria relating to the level that should be attained to adequately protect public health and welfare. Based on the wording of the Act and its legislative history, EPA interprets the Act as excluding any consideration of the costs of achieving those standards or the existence of technology to bring about the needed reductions in emissions. However, in compliance with the requirements of Executive Orders 11821 and 11949 and OMB circular A-107 and with the provisions of Executive Order 12044, EPA has prepared an assessment of the potential cost and economic impacts associated with efforts to attain alternative levels of the standard. This document presents the results of this assessment.

The purpose of the analysis contained herein is to estimate the relative ranges of national control costs for alternative levels of the carbon monoxide standard. In addition, in order to compare the relative implications of alternative standards, the estimated number of counties which might be expected to attain the alternative standards given various assumptions is also inidicated. Because of the many uncertainties in projecting emission levels and air quality levels and in determining effective control strategies throughout the nation, it is important to fully recognize that the results of the analysis should be viewed only as general guidance which provides an indication of relative differences in the attainment picture and the associated costs between alternative levels of the standard. The analysis cannot be used to precisely determine how many or which specific counties will attain a given carbon monoxide standard through particular control strategies. Rather, attainment status and control requirements for attainment will have to be determined for each geographical area based on the unique conditions that are inherent for that area. Likewise, this analysis cannot ascertain with a great degree of precision the costs of control strategies that will be required for all areas of the country to attain alternative standards. Since the actual control costs will be extremely variable, this analysis is useful in only presenting the relative implications for costs between alternative levels of the standard.

EXECUTIVE SUMMARY

This report presents economic impact information for alternative eight-hour carbon monoxide (CO) national ambient air quality standards of 7 ppm, 9 ppm, and 12 ppm.

Alternative one hour standards are not evaluated because attainment of any alternative 8-hour standard will assure attainment of any 1-hour standard under consideration. Impacts are assessed in terms of cost of control to affected industries, impacts on various consumer groups, impacts on distressed cities, and impacts on selected stationary and mobile sources.

Economic impact estimates in this report reflect 1987 annualized costs. These costs include direct costs of the Federal Motor Vehicle Control Program (FMVCP), annualized capital charges and annual operating and maintenance costs for air pollution control equipment for large stationary sources of carbon monoxide air pollution, annualized costs of operating inspection and maintenance (I&M) programs for mobile sources, and annualized capital charges for installing or constructing transportation control measures (TCM) for mobile sources pollution reduction. This assessment does not include costs incurred by state and local air pollution control agencies in implementing CO control activities because the proposed standard does not change the kind or amount of such activities undertaken by these agencies.

The estimated 1987 total nationwide cost to achieve a 9 ppm standard is approximately 3 billion dollars.

8-Hour Standard (ppm)	Cost of FMVCP ($$10^6$)	Cost of I&M ($$10^6$)	Cost of TCM ($$10^6$)	Cost of Stationary Source Control ($$10^6$)	Total Costs ($$10^6$)
7	2,380	450	60	10	2,900
9	2,380	410	40	10	2,840
12	2,380	210	0	20	2,610

The major portion of these costs, or approximately 2.4 billion dollars, is attributable to the control of motor vehicles under the FMVCP. Since this $2.4 billion is a fixed cost for all alternative standards, there is little difference in the total cost for any of the standards under consideration. Other major costs include those associated with motor vehicle inspection and maintenance programs. Less significant costs are associated with transportation control measures and emission controls on large stationary sources of CO air pollution. Depending on the level of the standard, these costs can range from approximately $0.2 to $0.5 billion.

Mobile source control programs are needed to control emissions of other air pollutants besides carbon monoxide. The programs also reduce emissions of volatile organic compounds and nitrogen oxides. Thus, there are joint costs involved in setting up and operating these control programs. The estimates in this document reflect only the CO portion of these costs.

Comparing total CO costs, the apparent incremental cost of going from a 12 ppm to a 9 ppm standard is $230 million. $200 million of this is attributable to I&M costs. However, because of the uncertainty in estimating the CO portion of total I&M costs, this value could be as low as $48 million, reducing the total incremental difference to $78 million. The apparent incremental cost of going from a 9 ppm to a 7 ppm standard is $60 million. Again, because of the uncertainty in estimating the CO portion of this cost, there could be a difference of only $36 million.

The impact of alternative CO standards on various consumer groups is investigated in the Urban and Community Impact Analysis (UCIA) portion of the report. This analysis shows that no particular segment of the population is forced to pay a disproportionate amount of the total cost of mobile source control. Therefore, there are no significant adverse income distribution impacts associated with any of the alternative CO standards.

The UCIA also investigates the impact of alternative CO standards on "distressed" cities. These cities are generally characterized by declining population, high unemployment, and low per-capita income. The analysis shows that around 80 percent of the urbanized areas that have to implement I&M and transportation control programs include a distressed city. This is not unexpected since it is principally a function of urbanized area size. The probable impact of CO control programs on distressed cities is negligible, however, since I&M is largely self-supporting (from consumer charges) and transportation control measures are mostly paid for by the federal government (via transportation systems management funds).

Cost and economic impacts of the three 8-hour alternatives were investigated for selected stationary sources. The analysis included capital and annualized industry control costs, availability of financial capital for control requirements, and potential product price and output impacts. Major findings are:

- Estimated capital costs range from $50 million for a 12 ppm standard to $80 million for a 7 ppm standard; capital costs for a 9 ppm standard are estimated to be $60 million.

- Estimated stationary source annualized control costs for the 12 ppm, 9 ppm, and 8 ppm alternatives are about $20 million, $10 million, and $10 million respectively. Fuel savings associated with control devices for the 9 ppm and 7 ppm alternatives account for the unusual ordering of control costs among the alternatives.

- Financial capital for pollution control is found to be generally available for plants requiring control for any of the three alternative standards.

- For affected industries and plants, controls associated with the alternative standards are judged to be economically affordable. No significant product output adjustments are anticipated in response to product price changes, which will be quite small for all alternative standards.

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1. SCOPE AND PURPOSE

The Clean Air Act, as amended in 1977, requires periodic review of the ambient air quality standard. This study, which reviews the National Ambient Air Quality Standard (NAAQS) for carbon monoxide, analyzes 1) the potential impact that feasible changes in the standard would have on national costs of control and on attainment status for various areas of the country, and 2) the potential socioeconomic impacts of these costs.

This section presents the study's background, scope, and organization.

1.1 REGULATORY CONTEXT

Executive Order 12044, Improving Government Regulations, calls for careful analysis of available regulatory alternatives, including the current standard, for new, significant regulations and for regulations already issued. The Environmental Protection Agency presented its plan to implement the Executive Order in the Federal Register of May 24, 1979 (Vol. 44, No. 104 FR 30988). The Regulatory Impact Analysis (RIA) presented here is designed to fulfill the requirements of Executive Order 12044.

At the present time there are two NAAQS's for carbon monoxide: an eight-hour standard of 9 parts per million (ppm), and a one-hour standard of 35 ppm.* Only the costs and impacts of the eight-hour standards are addressed in this study because: preliminary examination indicates that, in all cases, both the current and the alternative one-hour standards impose less stringent control requirements on both stationary and mobile sources than do the eight-hour standards. In all but a few cases, the control techniques used to attain the eight-hour standard are assumed adequate to guarantee attainment of the one-hour standard. The cost differences in those counties are more than compensated by more stringent eight-hour requirements in other counties. Therefore, there would be no significant incremental cost due to compliance with the one-hour standard.

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* Both standards are not to be exceeded more than once each year.

The regulatory analysis presented here examines the current eight-hour standard of 9 ppm as well as alternative levels of 7 ppm and 12 ppm. The revised NAAQS for CO is expected to fall within this range.

This study also examines potential cost and economic implications of a change in the form of the standard. Under its present form, attainment is determined by comparing the second highest monitor reading in any year to the standard. This "second-high" form of the NAAQS, while providing a relatively simple method for determining attainment, can lead to a designation of nonattainment if a meteorological anomaly should occur. To account for this distortion, several statistical forms of the standard are considered, with particular attention paid to the standard which uses the expected value of the daily high reading for the year. This daily form is the same form of standard chosen for the new ambient standard for ozone (EPA, 1979). A complete discussion of the alternative forms of the standard and the implication of each is presented in Section 3, "Mobile Source Costs."

1.2 STUDY OBJECTIVE

The primary objectives of this study are to:

- Determine the cost of attaining the National Ambient Air Quality Standard by
  - providing costs for the current standard
  - estimating the differential cost between alternative levels and forms of the standard

- Study the economic impacts of the control on
  - consumers and motorists
  - State and local government fiscal situations
  - industry production and pricing
- Determine the major sensitivity of results to certain study variables.

Each of these objectives is discussed below.

1.2.1 Cost Estimates

The cost estimates consist of the direct costs of control measures which require carbon monoxide control including the Federal Motor Vehicle Control Program. In cases where the control of more than one pollutant is achieved by a particular control measure, the costs are apportioned among the various pollutants. The method of apportionment is described in the Cost Methodology sections.

The cost estimates reflect the total annualized cost of attainment of the CO standard. This includes annualized capital charges on equipment as well as annual operating and maintenance/repair costs. Also included in the annualized cost are estimates of potential savings due to decreased energy requirements resulting from control strategies.

It should be noted that no consideration is given here to SIP development costs.

1.2.2 Economic Impacts

The second primary objective of this study is to assess the economic impacts of the costs imposed by the control requirements. The economic impacts are divided into three areas depending on where the direct effect is felt. The particular cost components differ between various control techniques but include estimates of costs imposed on industry, government, and individuals.

Impacts on individual consumers arise primarily from mobile source control costs and are examined in two ways: per capita impacts and macro-economic impacts on the distribution of income.

Related to and presented with the consumer impacts is an Urban and Community Impact Analysis (UCIA). Mandated by the Office of Management and Budget (OMB, 1978), the UCIA provides analysis of the impacts on minorities, employment, income, and cost of living.

The second area of economic impact analysis involves the ability of State and local governments to handle the cost of establishing and maintaining the programs required to meet the standards. These government units bear the direct cost of the programs. The extent to which any burdens are placed on already distressed cities is examined in the UCIA.

The final area of economic impact analysis concerns the effect of control costs on industry. These impacts result from the costs of stationary source control and are examined both in terms of the capital requirements imposed on industry and the ability of companies to bear the capital expense and in terms of the inflationary and competitive impact of annualized costs on production costs and product prices.

1.2.3 Sensitivity Analysis

The final objective of the study is to determine how sensitive the results are to certain assumptions. Exogenous variables such as growth rates and control effectiveness are examined using different assumptions to determine sensitivity of resulting costs. The different forms of the standard also are analyzed to determine the significance of any such changes. Certain of the sensitivity analysis scenarios are deemed to be significant and therefore are subject to complete analysis.

1.3 ORGANIZATION OF THE REGULATORY IMPACT ANALYSIS

Section 2 presents the study methodology. While it provides an overall view of the study, it does not present complete methodologies of each analytical component; rather, it indicates what the components of the study are and shows how the various analytical pieces interact to produce the estimated cost of attainment. Section 2 also presents the total annual costs of attaining the current as well as the alternative eight-hour standards. The costs represent a summary of the components calculated in later chapters.

Section 3 presents the methodology for and results of the cost estimation for mobile source control measures. Included is a discussion of the procedures used to determine the amount of emission reduction needed, the control strategy selected to attain the standard, and the degree of reduction and associated cost produced by the control measures. Estimates are made of the number of counties which will comply with the standard by 1987 using the control strategies under consideration. Results for various sensitivity analysis scenarios also are presented.

Section 4 presents the results of the stationary source cost analysis by industry. The methodology and assumptions used to calculate these costs are presented in Appendix B.

Section 5 contains an analysis of the economic impacts of the mobile source control requirements. The impacts are discussed for each level of the standard. Also examined are the sensitivity analyses for scenarios deemed to show significant impact on the results. Section 5 also presents the results of Urban and Community Impact Analysis.

Section 6 shows the results of the stationary source economic impact analysis. The results are intended to indicate industries for which the cost of control may present potential problems. No Urban and Community Impact Analysis is included for stationary sources since their costs were always less then one percent of the total cost of CO control from all sources.

REFERENCES FOR SECTION 1

U.S. Environmental Protection Agency. January 1979. "Cost and Economic Impact Assessment for Alternative levels of the Ambient Air Quality Standard Ozone."

U.S. Office of Management and Budget. August 16, 1978. Circular No. A/16.

2. STUDY METHODOLOGY AND TOTAL COST

This section presents the total annualized cost of attaining alternative National Ambient Air Quality Standard (NAAQS) and various alternative standards for carbon monoxide. Figure 2-1 depicts the general procedure followed to determine the total cost of control. The program through which attainment is achieved consists of three areas of emission control: the Federal Motor Vehicle Control Program (FMVCP), in-use mobile source control, and stationary source control.

2.1 CONTROL PROGRAMS

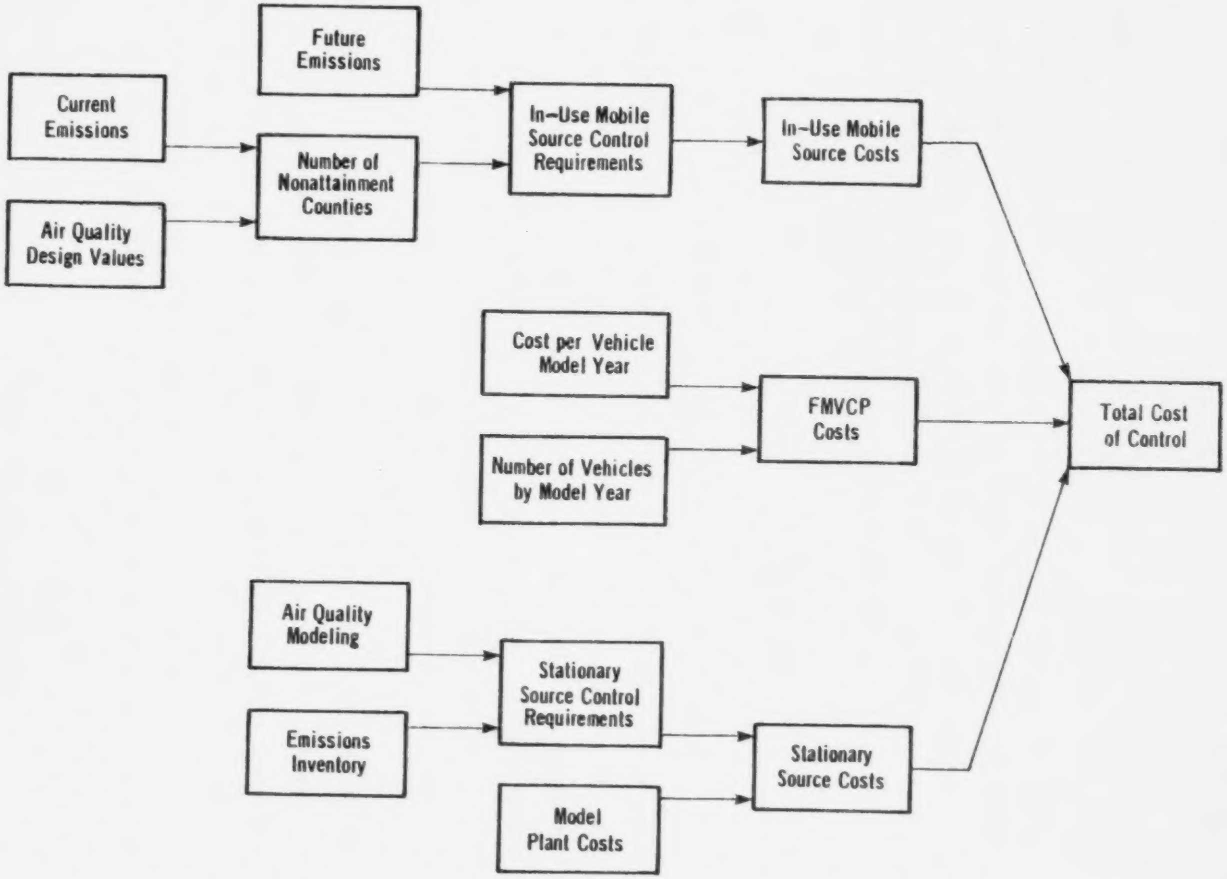
2.1.1 Federal Motor Vehicle Control Program

The Federal Motor Vehicle Control Program provides substantial emission reductions across the country and their resulting costs comprise a basic component of the program to attain the NAAQS for carbon monoxide. While FMVCP control requirements are not directly related to the NAAQS program, they provide a baseline emission reductions guideline upon which the current and alternative standards can be based.

FMVCP includes a series of increasingly stringent tailpipe emission standards with which new motor vehicles must comply. The program includes control of light-duty vehicles, light-duty trucks, heavy duty trucks, motorcycles, and aircraft. The emission standards set by the program become increasingly stringent for later model years; thus, as more early model vehicles are retired, total fleetwide emissions are reduced.

Since the emission standards require different control technologies, the costs are calculated separately for each model year. A complete discussion of the methodology and results of the costs incurred due to FMVCP appears in Appendix A.

FIGURE 2-1
STUDY METHODOLOGY
FOR COST OF ATTAINING CO STANDARD


Current Emissions
Air Quality Design Values
Future Emissions
Number of Nonattainment Counties
In-Use Mobile Source Control Requirements
In-Use Mobile Source Costs
Cost per Vehicle Model Year
Number of Vehicles by Model Year
FMVCP Costs
Total Cost of Control
Air Quality Modeling
Emissions Inventory
Stationary Source Control Requirements
Model Plant Costs
Stationary Source Costs

2.1.2 In-Use Mobile Source Control

Control programs used to achieve additional reductions in mobile source emissions necessary to attain NAAQS are aimed at reducing emissions from in-use vehicles. For purposes of this analysis, such measures include Inspection and Maintenance (I/M) programs for light-duty vehicles and Transportation Control Measures (TCM) which reduce emissions by reducing travel and improving traffic flow. In designated nonattainment counties (those needing emission reduction), the amount of reduction is determined by current emissions, projected future emissions, and the air quality levels that are present within any county.

While the actual cost of these measures will vary considerably among local areas, this analysis uses average costs based on studies of programs already implemented in local areas. The magnitude of the cost in individual counties is dependent on the county vehicle population and the degree of emission reduction required. The particulars of the cost algorithm are presented in Section 3.

Because of the different nature of mobile source and stationary source emission problems and the location of the existing monitoring network, it is believed that recorded violations in nonattainment areas are a result of mobile sources and localized area sources. As part of this study, an analysis of the stationary source problem was conducted which indicates that stationary source emissions had negligible effects on monitor readings in most counties. Therefore, all of the needed reductions in each nonattainment county are provided by control of mobile source emissions.

2.1.3 Stationary Source Control

Stationary source control requirements were determined by examining the maximum air quality impact from individual sources in isolation. Source-specific data for emission and stack parameters were used to determine the maximum air quality impact of the plant's emissions.

Model plants were used to estimate the unit cost of alternative control techniques for each source category. The total cost of controlling point source emissions was calculated by applying the average unit cost data to actual levels of operation at each source. The costs were aggregated to obtain a national total. A more complete discussion of the calculation methodology is presented in Appendix B; the results are discussed in Section 4.

2.2 TOTAL COST

As discussed in Section 1.1, while the NAAQS for CO is expressed as both a one-hour and eight-hour standard, only the eight-hour standard alternatives are examined here since, for purposes of this study, compliance with the eight-hour standard assumes compliance with the one-hour standard. The control requirements estimated by this study for the current eight-hour standard levels of 9 ppm and two alternatives of 7 ppm and 12 ppm provide emission reductions necessary to meet almost all one-hour standards as well. While there are some exceptions, the total control expenditures for the eight-hour standard will exceed any one-hour expenditure within the level of confidence of this study.

Table 2-1 presents the costs of complying with the alternative NAAQS's. It should be noted that these costs do not include estimation of any cost of administering the standard. All costs represent net annualized costs incurred in 1987 measured in 1979 dollars. Any benefits in fuel consumption for mobile and stationary sources are included. The costs estimated for compliance with each standard depend on assumptions made for each scenario. These assumptions include varied estimates of growth in emissions, control program effectiveness, and initial air quality levels as well as policy decisions regarding the level and form of the standard. In addition to the three levels of primary case, which assume the form of the standard consistent with the revised ozone standard, costs are presented for the 9 ppm second-high standard and the 9 ppm daily standard (the latter assuming regional variation in emission growth). A complete discussion of these assumptions appears in Section 3.

TABLE 2-1

TOTAL ANNUALIZED COST OF ATTAINMENT

(1979 $\$10^6$)

Control	7 ppm	Primary Case[a/] 9 ppm	12 ppm	9 ppm 2nd[b/] High	9 ppm Daily[c/] Regional Growth
FMVCP	$2378	$2378	$2378	$2378	$2378
Stationary Source	9	15	22	15	15
Additional Mobile Source					
I/M	449	411	214	507	458
TCM	57	36	-4.7	35	84
TOTAL	$2893	$2840	$2609	$2935	$2935
Percentage from 9 ppm primary case	+1.8%	---	-8.1%	+3.3%	+3.3%

---

a/ Primary case assumptions categorize CO air quality problems as being "hot spot" rather than area-wide. The primary case also assumes the choice of the daily form of the standard.

b/ The second-high standard is the current form of the CO standard. This scenario assumes a 1 percent per annum increase in emissions.

c/ Regional growth scenario assumes an area-wide CO problem. Emissions are grown by regional statistics in this case.

The assumptions contained within the primary case were chosen by EPA as the basis for this study in order to provide an examination consistent with the ozone standard. It should be noted throughout this report that the primary case is not the current standard. The 9ppm second-high case is the current eight-hour standard.

The total cost of control under the 9ppm primary case is $2.8 billion. Over 84 percent of this cost results from FMVCP control costs with only one-half of one percent resulting from control of stationary sources.

Using the same assumption, the 7ppm primary case costs $2.9 billion. This is an increase of less than two percent above the 9ppm standard. Of interest is the decrease in the stationary source control cost from $15 million to $9 million per year. This results from fuel credits obtained from the carbon monoxide control technology. A complete discussion of these credits is presented in Chapter 4 (Costs) and Appendix B (Methodology).

The 12ppm primary case has a total annualized cost of $2.6 billion or a reduction in cost of 8.1 percent relative to the 9ppm level. This results from 53 percent decline in the total cost of additional mobile source control (i.e., control above minimum inspection/maintenance requirements). Under this scenario, the stationary sources account for 0.8 percent of the total cost. This is the largest contribution for all scenarios.

The 9ppm second-high standard results in a 3.3 percent increase in annualized cost above the 9ppm primary case. Since this represents the current standard, an estimated cost of $2.9 billion per year would occur if the standard is not changed.

Also presented is a 9ppm daily regional growth scenario. This case uses the same form and level of the standard as the primary case but assures a larger emissions base line.

Again, the result is an estimated cost which is 3.3 percent greater than the primary case. This results mainly from an increase of 233 percent in required transportation control measures.

No difference in the cost of control for FMVCP or stationary sources is assumed for scenarios considering alternative forms of the standard. Neither of the programs depends upon measured air quality and, therefore, the costs are not dependent upon the form of the standard or the emission growth scenario. In fact, FMVCP costs are completely independent of the level of the standard as well.

When the cost of mobile source control is added to the cost of stationary source control and FMVCP, the total fluctuation in cost between these scenarios runs from +3.3 to -8.1 percent. Under the primary case assumption, the cost increases as the stringency of the standard increases -- a result which is not unexpected, due to additional control requirements of the more stringent standard.

3. MOBILE SOURCE COST

Mobile sources account for over 80 percent of the mass of carbon monoxide emitted in the United States (EPA, 1979d). Since the CO problem in most urban areas is caused by mobile sources, the majority of CO control costs will be borne by the mobile source sector.

This section provides information about 1) the process by which the cost estimates were made, including the method by which needed reductions are calculated, 2) control strategies, and 3) costs of control. In addition, the critical assumptions made are presented along with their sensitivity analyses.

Complete details of the procedure for determining mobile control requirements and resulting costs can be found in a report produced by Stanford Research Institute, entitled "Methodologies to Conduct Regulatory Impact Analysis of Ambient Air Quality Standard for Carbon Monoxide" (SRI, 1979).

3.1 COST ESTIMATION PROCESS

The process by which cost estimates were made includes determining baseline emissions, air quality design values, and needed reductions.

3.1.1 Baseline Emissions

Baseline emissions data are calculated to provide information on the magnitude of CO emissions in each of 272 counties. These counties are considered either to be in nonattainment under the current standard or to be potentially in nonattainment under one or more of the alternative standards. The base year emission inventory comes from EPA's existing emission data base. Projections of emissions for three critical future years are made taking into account growth as well as the mandated tailpipe emission standards for motor vehicles.

Emissions projections are made for the years 1982, 1984, and 1987. 1982 represents the year in which areas must demonstrate attainment of the standard (Clean Air Act, 1979); however, this date is relevant only if the NAAQS is either maintained at the present level or relaxed. If the standard is made more stringent than the current level, areas are given a two-year extension because of the lead time for rulemaking provisions and SIP revisions. In that case, the emissions projection for 1984 is used. If the standard cannot be met by the dates indicated, an extension to 1987 is allowed, provided that the area implements an inspection/ maintenance program and demonstrates reasonable further progress in attaining the standard. The projection of 1987 baseline emissions is used as an estimate of emissions that would be present in that year in the absence of additional control programs.

The baseline emissions data include contributions from both mobile and area sources, with mobile source emissions as the primary contributors. The current mobile source data are obtained from the National Emission Data System (NEDS) file for 1976-1979 (EPA, 1979a) and were assumed to represent 1976 emissions; growth factors therefore were used to transform 1976 emissions to the 1979 baseline.

Projection of future mobile source emissions in 1982, 1984, and 1987 were calculated using MOBILE1, EPA's mobile source emission model which incorporates the latest emission factors (EPA, 1978). The emission projections take into account growth in vehicle miles traveled (VMT) and reductions in tailpipe emissions expected from the Federal Motor Vehicle Control Program. The projections assume that the 3.4 gram/mile CO standard for light duty vehicles is instituted in 1981 as mandated by the Clean Air Act. The impact of the recent waiver decision is not incorporated, though the change in fleet-wide emissions will be small and will have a negligible impact on the results of this analysis (see p. A-13).

MOBILE1 accounts for the increase in CO emissions as ambient temperature decreases. There are four different classes of vehicles which were used to model the emissions versus temperature relationship given in MOBILE1: 1) pre-1968 model year vehicles, 2) 1968-1974 model year vehicles, 3) 1975 model year non-California vehicles, and 4) 1975 model year California vehicles. Each class of vehicles has its own CO versus temperature adjustment factor curve.

Special attention must be given to the CO-versus-temperature adjustment curves for the 1975 and later model year category. The data that were used to generate the relationship used in MOBILE1 came primarily from 1975 model year vehicles. Since technology for the 1975-1979 model year vehicles did not change substantially, the relationship of the 1975 model year Federally owned vehicles is assumed applicable through 1979. For 1980 and later models, the relationship of the 1975 model year California vehicles was used. However, the emission control technology that will be used on future model year vehicles (especially those for model year 1981 and later) is expected to be substantially different from that used on the 1975 model year California vehicles. Therefore, it is also possible that the CO versus temperature behavior of the future vehicles also could be substantially different.

Because of the sophisticated nature of future systems, the possibility exists that the CO versus temperature relationship could be relatively worse or relatively better than is estimated by MOBILE1. This introduces some uncertainty into the analysis. EPA is conducting studies to improve the estimates of the CO versus temperature effect for future vehicles, but they are not complete at this time. In order to perform this analysis, the MOBILE1 projections were used as a best estimate.

The estimation of emissions is based on county-specific data including ambient temperature and altitude, since these factors influence total CO emissions. A special category for California counties is created to account for more stringent State standards for mobile sources.

Area source emissions also contribute to the baseline emissions inventory. Area sources include residential heating and some processes too small to be individually identified. Current area source emissions were also obtained from the NEDS data file. Future area source emissions were calculated using the current emission and a one percent per year growth rate in emissions (SRI, 1979).

The total baseline emissions are equal to the sum of mobile source and area source emissions. This calculation was performed for all counties in the analysis.

3.1.2 Air Quality Design Values

The design value for an area represents the estimated ambient CO concentration from which emission reductions are calculated in the strategy planning process. Design values which are used in this analysis were obtained from a review of 1976-1978 ambient air quality data in EPA's SAROAD data base, which comes from an extensive monitoring network. The data base represents the only readily available source of consistent data for all of the areas investigated. Sufficient data are contained in the data base to estimate the approximate values based on the alternative forms of the standard.

The design values included in this analysis are approximate and suitable only for analytical purposes in this assessment. In SIP revisions submitted to EPA, States will calculate the actual design values used for attainment determinations and for planning purposes. The values will be calculated for the appropriate form of the standard based on guidance provided by EPA (see CFR Part 51.)

The current CO standards specify that the eight-hour averages must not be exceeded more than once per year. In addition to assessing alternative standard levels in this analysis, alternative procedures for calculating exceedances of the standard also are considered. These procedures affect the form of the standard. Not only does the form influence the determination of the number of exceedances of the standard, but it also impacts the calculation of an area's design value.

In its current form, the standard is based on the highest monitored value during a year in an area. However, this deterministic (once-per-year) approach has limitations in that it does not account for the probabilistic nature of maximum CO concentrations. To maintain such a standard year after year necessitates a zero probability that the second-high value will ever exceed the standard. On a practical basis, permitting only a single absolute exceedance in a year means that there is some possibility of occasionally having two or more exceedances in a particular year.

To remedy this conflict and to adjust for the effect of missing data, EPA is considering defining the standard on a statistical basis whereby the expected number of exceedances per calendar year is determined. Statistical forms of the standard vary depending on whether all possible values or just daily values are used, and how running averages are handled for the eight-hour standard.

For purposes of the analysis contained in this document, two interpretations of the statistical standard are used. For the one-hour standard, the hourly interpretation bases the design value on the ambient hourly concentration that on average will be exceeded once per year in each area. The daily interpretation, on the other hand, bases the standard on the number of days with maximum hourly CO averages above the level of the standard. This means that a day with two or more hourly values over the standard level counts as one exceedance of the standard level rather than two or more.

Statistical forms of the eight-hour standard follow the same basic approach, but the interpretation is complicated by running averages, as discussed by EPA in "Guidelines for the Interpretation of Air Quality Data with Respect to the National Ambient Air Quality Standards" (EPA, 1977). The current CO standard is chosen so that the second exceedance will not come from an eight-hour period which contained at least one hour in common with the first exceedance.

In calculating design values for use in this analysis, the daily interpretation uses overlapping eight-hour averages in computing the expected number of exceedances. For each day, the highest of the 24 possible eight-hour averages is the daily maximum eight-hour average. With this method, the possibility arises that two daily exceedances could have common hourly values. The other statistical approach (the hourly interpretation) employed in this analysis uses all possible eight-hour averages for the year so that more than one exceedance per day could be counted. This is more stringent than the current form of the standard in that exceedances could be overlapping.

In the analysis of the three years of data from 1976 to 1978, design values based on the eight-hour statistical forms of the standard are expected to fall between the third and fourth highest maximum value (whether hourly or daily). In selecting design values, the fourth highest value over the three year period was used. If only two years of data were available, the third highest value was chosen.

While design values are available for all major urban areas which comprise 60 to 70 percent of the nation's population, many non-urbanized areas of the country do not have valid air quality monitoring data from which to judge whether the area has a CO problem. For these areas, emission densities in the county were obtained in order to gain an indication of the potential problem in the county. These values then were compared to equivalent emission densities which serve as compatible surrogates for the various standard levels. A basic air pollution model was used to calculate equivalent emission densities that would lead to a concentration equal to the levels of the standard under a certain set of conservative conditions (SRI, 1979). Thus, for those counties not having design value data, emission densities are used as design value surrogates.

3.1.3 Assumptions Made in Calculating Needed Reductions in Mobile Source Emissions

One of the most controversial areas of air pollution analysis is the relationship between emissions and monitored air quality values. Changes in relative location of emission sources and air quality monitors can radically alter the air quality readings. Therefore, all emissions within a county do not contribute equally to air quality readings.

The amount of emission reduction required in each county to meet each of the standards under consideration is calculated through the use of the modified rollback procedure (SRI, 1979) which assumes a linear relationship between emissions and air quality. In other words, a 10 percent improvement in the air quality design value is calculated to require a 10 percent reduction in emissions.

3.1.4 Calculation Procedure

The percent rollback was calculated for each county with a design value in the following manner:

$$\text{Percent rollback} = 100 \times \frac{(\text{Design value}) - (\text{Standard})}{\text{Design value}}$$

This provides a percentage indicating the amount of improvement in air quality necessary to meet the standard. For counties where design values do not exist, the rollback is calculated by the following equation based on emission density data:

$$\text{Percent Rollback} = 100 \times \frac{(\text{Total emission density, tons/mi}^2\text{/yr}) - (\text{Standard Density})}{\text{Total emission density}}$$

where the standard density is an estimate, calculated by EPA, of emissions per square mile that result in air quality readings equal to the standards.

Both of these calculation procedures provide an estimate of the percent improvement in air quality required to meet the standard. Once this is accomplished, the allowable emissions are calculated for each county under each standard. The allowable emissions are defined as the maximum level of effective emission within a county that produces air quality readings that comply with a particular standard, as calculated by the rollback procedure:

$$\text{Allowable emissions} = \left(1 - \frac{\%\ \text{rollback}}{100\%}\right) \times (\text{Current Effective 1979 emissions})$$

The concept of effective emissions is used to reflect the relative impact of various source categories. The effective emissions are obtained by considering the current or future baseline emissions and weighting the components by factors chosen to estimate the relative contributions of different sources to air quality readings. Based on results of modeling studies, the assumption is made that only a portion of the total area source emissions contributes to an area's maximum CO values, which comes from sites that reflect more localized sources. For purposes of this study, the effective emissions which are assumed to impact monitored values are equal to 100 percent of mobile source emissions and 20 percent of area source emissions (SRI, 1979).

Since point source emissions do not affect air quality readings and no area source control measures are considered, any reduction required to meet the allowable emissions level must be supplied through control of mobile source emissions. Thus, the needed mobile source reduction equation is:

Needed mobile source reduction = (Total effective emissions in any year) -
(Allowable effective emissions)

The needed reductions were calculated for 1982, 1984, and 1987 for current and relaxed standards and for 1984 and 1987 for more stringent alternative standards.

Point source emissions (i.e., those from major industrial processes) are not considered to contribute to monitored CO values. The stationary source analysis (presented in Section 4 and Appendix B) indicates that point source emissions have negligible effects on monitored readings in most counties.

Since it is the design value and not the emissions which determines whether or not a county requires additional control, no counties are exempted from the need for additional control by the assumption of the reduced effect of area source emissions. The assumption causes mobile source emissions to be weighted more heavily in attainment strategies to simulate observed contributions. A further discussion of this is presented as part of the discussion on growth sensitivity in Section 3.4.2.

3.2 CONTROL STRATEGIES: COST DEVELOPMENT AND EMISSION REDUCTION

The mobile source control strategies considered in this study are divided into two types: Inspection and Maintenance (I/M), and Transportation Control Measures (TCM). The TCM programs include both area-wide measures, which are designed to reduce total travel in an area, and localized measures, which respond to "hot spot" problems by improving traffic flow.

While the cost and effectiveness of both I/M and TCM programs vary depending upon the characteristics of the individual areas and programs, this study uses average cost and reduction estimates for the programs to calculate total cost. These average costs are based on studies of programs that have been implemented in selected local areas across the country.

3.2.1 Inspection/Maintenance Program

3.2.1.1 Description of Programs Used

The nonattainment provisions of the Clean Air Act (Sec. 172(b)11-13) require that an area that cannot demonstrate attainment by 1982 must establish an I/M program (Clean Air Act, 1977). The intention of Congress was to have this control measure operate as the basic technique in reducing mobile source emissions from in-use vehicles by requiring maintenance and repair of vehicles which do not pass a tailpipe emission test. EPA's interpretation of the Act and subsequent policy decisions has resulted in the requirement that I/M programs be implemented, where necessary, no later than December 31, 1982.

Fleet-wide emission reductions will be dependent on a number of factors, one of which is the percentage of vehicles that are designed so that they fail the test and thus have to undergo repairs. Other influencing factors include ambient temperature, location, year of implementation, and extent of mechanic training achieved by an I/M program.

Table 3-1 presents the emissions reductions in the target year (1987) for I/M programs using 20 and 30 percent failure rates. The table also indicates that the amount of reduction obtained in 1987 is dependent upon the number of years the program has been in operation, while the year in which the program starts is dependent upon a status schedule generated by EPA (EPA, 1979c). Presently, many areas in the United States are required to establish I/M programs for the control of CO/HC emissions in order to meet current ambient air quality standards for CO and/or ozone. It is assumed that any area with this designation will initiate its I/M program in July 1982.

Some counties are identified as needing emission reduction for attainment of one of the more stringent alternative CO standards, without currently

TABLE 3-1

PERCENTAGE REDUCTIONS MADE IN MOBILE SOURCE EMISSIONS IN TARGET YEAR 1987 FROM I/M PROGRAMS FOR LDV'S[a]

Location	Percent Failure Rate	Percent Reductions Initiation Year 1982	1983	1984
Low Altitude	20%	19%	17%	14%
	30	23	20	17
High Altitude	20	19	17	14
	30	23	20	17
California	20	17	15	12
	30	20	18	15

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[a] Reductions achieved in total mobile source emission resulting from I/M programs for light duty vehicles. Other vehicle classes are not required to be inspected.

needing an I/M program. If such a county is located in a State which has I/M legislation, it is assumed that the county will implement I/M in July 1983. In a State where there is no previous legal authority for I/M, a county needing reductions is assumed to begin the program in July 1984. This is to account for the lead time needed to obtain legislative authority at the State level.

In urban areas, auto emissions affect the air quality of the entire area, not just the county in which the specific problem occurs. Emission reductions can be guaranteed only if every county in the urban area implements an I/M program similar to that required in the problem county. It therefore is assumed that an urbanized area (as specified by the Bureau of Census) which requires control in some of its counties must implement an I/M program at the tightest stringency level required for them and then must implement the same program in all of its other counties as well.

3.2.1.2 I/M Costs

Costs for I/M programs which are presented in this analysis are indicated for the year 1987; this is the year by which the CO NAAQS should be attained. The annual expenditure required for an I/M program is divided into inspection cost, repair cost, and fuel savings (a negative cost). The total costs for each area implementing I/M are calculated by estimating the vehicle population in 1978 and multiplying the number of cars affected by the unit costs.

The inspection cost, levied on each car, is designed to include the costs of operating and maintaining the program and an annual capital charge to pay for the inspection facility. While these costs can vary from $2.50 to $14.00 depending on the particular program, the average cost is assumed to be $7.00 for each car inspected (EPA, 1979b). Cars which fail the inspection will be required to undergo repairs in order to correct the problem. Preliminary data from EPA's intensive study of the I/M program in Portland, Oregon, indicate that the average cost of necessary repairs is $28 per failed vehicle. This average cost was used to generate total repair costs for this study (EPA, 1979b).

While improved operation of repaired vehicles might be expected to result in savings in fuel consumed,* recent information indicates that current technology cars are not experiencing fuel economy benefits. Data from the Portland study indicate that repaired vehicles representing current model years are not realizing the fuel economy benefits once anticipated. However, because of the configuration of future emission control systems, it is anticipated that fuel economy benefits may result from improved maintenance in post-1980 cars. In order to capture this uncertainty, two cases are presented whereby 1) no fuel economy benefits are included for any model years, and 2) a fuel economy benefit is estimated for post-1980 cars only. In this latter case, EPA's motor vehicle technical staff indicates that, based on engineering judgement, an estimated fuel economy improvement of an average of 7.5 percent may be realized for affected vehicles under a 20 percent stringency program and an average of 6.0 percent under a 30 percent stringency program. The average fuel economy improvement per repaired vehicle decreases as the stringency increases, due to the reduced incremental improvement of the additional cars repaired.

Unit costs presented here do not include allowances for the costs of peoples' time to have their cars inspected and repaired. While people admittedly will suffer some inconvenience from I/M programs, the costs of such losses in time are not expected to be large since the actual inspection lasts only a few minutes and likely will be coupled with normal travel in the vicinity of the inspection station. Moreover, the real maintenance costs may be overstated somewhat since much of the maintenance will be performed during normal auto care. As a result, the overstatement of the repair costs probably offsets any costs attributed to peoples' time.

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* Total fuel savings are calculated based on assumed values of 430 gallons per year per car and $1.00 per gallon of gasoline.

3.2.1.3 Allocation of I/M Costs for CO Control

The costs calculated in the previous section represent the total cost of implementing I/M in any county. Recall, however, that counties specified by EPA as implementing I/M in 1982 do so because of the need for both CO and HC emission control. Total I/M costs should not be attributed totally to CO control, rather they should be equally divided between the two pollutants. Therefore, annual I/M costs are divided by two for all counties instituting I/M in 1982. For other areas which are identified in this analysis as needing I/M for CO control but which do not have current plans to implement a program by 1982, all of the costs are attributed to CO since HC control is not necessarily needed.

3.2.2 Transportation Control Measures

3.2.2.1 Program Description

Transportation Control Measures reduce emissions by reducing vehicle miles traveled (VMT) or by improving traffic flow. Control measures include transit system improvements, ridesharing programs, road user charges and congestion pricing, traffic signal system improvement, and exclusive bus or car pool lanes. These methods are categorized as either local or area TCM measures.

Local TCM's include signal timing, computerized control of street flow, freeway surveillance and control, and truck restrictions on certain streets. These measures are intended to improve traffic flow and alleviate CO "hot spot" problems. Areawide TCM's, which include ridesharing, express buses, local bus improvements, work rescheduling, and monitoring criteria, are intended to reduce total emissions in an area by reducing VMT and the number of trips.

TCM options are used in addition to I/M in counties where I/M is not sufficient to provide needed reductions or where the needed reduction is 5 percent or less (assuming no other county in the urbanized area requires I/M. See Section 3.2.1.1).

3.2.2.2 TCM Cost

Emission reductions and costs per unit of reduction of TCM controls can vary significantly depending on local conditions. However, EPA has undertaken an assessment of TCM's in order to determine generalized emission reductions and costs for use in this analysis (SRI, 1979). As a result, an estimate of up to a 3 percent reduction in mobile source emissions is assumed to be obtained through local TCM. Although the measures will be somewhat different depending on the locality, the cost of such measures is estimated at $170/ton of CO reduction (SRI, 1979).

Area-wide TCM may reduce emissions by an additional 2 percent. The marginal cost of these reductions, however, is not constant. The first one percent reduction in emissions from area TCM is estimated to cost $400/ton of CO reduced with the last one percent costing $9400/ton reduced (SRI, 1979). The last one percent includes such costly measures as transit improvements.

A byproduct of reducing VMT is a reduction in fuel consumption. By reducing total travel, a factor of 1088 gallons/ton of CO reduced is used to estimate these fuel savings (SRI, 1979). This value then is subtracted from the annual cost to estimate the net annual cost of the program.

As in the case of I/M, only a portion of these costs are attributable to CO control. Since TCM also can be used to control HC, reduce traffic congestion and travel time, and save energy, this analysis allocates a maximum of 50 percent of the cost and savings to CO control.

3.2.3 Total Cost of Mobile Source Control

The total annual net cost of mobile source control is the sum of three components for each area: 1) the CO portion of the cost of FMVCP plus, 2) the I/M cost plus, 3) the TCM cost.

3.3 COST OF ATTAINING CURRENT AND ALTERNATIVE STANDARDS*

3.3.1 Primary Case Assumptions

The cost of the regulatory primary case reflects expenditures required in response to the NAAQS for CO plus the costs of complementary mobile source emission programs (e.g., FMVCP) which will not change under alternative NAAQS's. Further, the primary case includes the incremental expenditures required to eliminate current nonattainment, assuming the current standard is retained.

In this analysis, primary case costs consist of the CO share of expenditures for FMVCP and for the 9 ppm, 8-hour average standard. Several assumptions underlie these baseline costs:

- Form: the eight-hour average is calculated as a daily interpretation of the statistical form
- Effectiveness: I/M realizes all of expected reductions at cold temperatures
- Growth: VMT and area source emissions grow at a one percent per annum rate ("hot spot" growth scenario)
- FMVCP: a tailpipe standard of 3.4 grams/mile is instituted in 1981

In the following subsections, the costs of this primary case will be presented for the alternative levels of the standard. In addition, the impact on cost of changing one or several of the above assumptions will be examined and compared to the primary case as a test of the sensitivity of the cost to the analytical assumptions and the eventual regulatory structure.

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* The costs presented here deal with the eight-hour standard only (see Section 1.1).

3.3.2 Federal Motor Vehicle Control Program

The FMVCP controls tailpipe emissions of CO, hydrocarbons, and nitrogen oxides from cars, trucks, motorcycles, and aircraft. Appendix A presents an analysis of the program's cost for these vehicle categories as well as a discussion of the rationale for allocating certain FMVCP costs to CO. Table 3-2 summarizes the total 1987 FMVCP cost attributable to CO. In general, costs were divided equally among the pollutants controlled by each phase and/or component of the program (i.e., one, two, or all three).

The costs for light-duty vehicles assume that 1981 and later model year cars meet the 3.4 grams/mile emission standard as mandated by the Clean Air Act. While there are several alternative technologies which might be used to achieve the standard, most auto manufacturers plan to use a three-way catalytic converter in combination with an oxidation catalyst, the latter primarily for CO control. The costs presented in this analysis reflect the allocation of estimated costs for such a system among CO, HC, and NO_x.

In addition to the hardware costs, the annualized costs also include estimates of the costs or savings resulting from changes in operation and maintenance, changes in fuel economy, and fuel price differentials. The underlying rationale for these estimates is presented in Appendix A.

The total annualized cost in 1987 attributed to CO, $2.5 billion is incurred regardless of the level or form of the standard; hence, it remains a constant cost in all scenarios. It should be noted, however, that the cost of FMVCP and the emission reduction achieved will both be reduced by any two-year waiver of the 3.4 grams/mile standard for two years.

TABLE 3-2

TOTAL ANNUAL COST OF THE FMVCP IN 1987
(1979 $\$10^6$)

Type of Vehicle	Annual Cost of CO Control
Passenger Cars (LDV)	
Hardware	$2003
Fuel economy	(1710)[a]
Unleaded gasoline cost	733
Operating and maintenance	(639)[a]
Altitude controls	278
Total	665
Light-Duty Trucks (LDT)	
Hardware	740
Fuel economy	0
Unleaded gasoline cost	354
Operating and maintenance	0
Altitude controls	100
Total	1194
Heavy-Duty Vehicles (HDV)	
Hardware	126
Unleaded gasoline cost	305
Total	431
Motorcycles	
All costs	46
Aircraft	
All costs	42[b]
TOTAL	$2378

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[a] Costs savings.

[b] Preliminary aircraft cost subject to future conformation or change.

3.3.3 Cost of Attaining Current and Alternative NAAQS Level

Table 3-3 presents the annualized cost, by control program element, of achieving a 9 ppm standard (daily eight-hour average). The cost presented is a net cost, accounting for fuel savings obtained through I/M, TCM, and FMVCP. Total costs amount to approximately $2.66 billion in 1987. The gross cost (i.e., without fuel savings) is $2.82 billion.

Under the eight-hour, 9 ppm daily standard, most counties will be able to achieve emission reductions sufficient to demonstrate attainment. Table 3-3 indicates, for each standard level, the number of counties which will remain in nonattainment after full utilization of the control strategies considered in this analysis. Using the primary case assumptions, only a couple of counties may not be able to achieve the standard in 1987 with FMVCP, I/M, and TCM.

The costs associated with alternative levels of the air quality standard for CO also are presented in Table 3-3. Under a 7 ppm standard, the total annualized gross cost (excluding fuel savings) increases to $2.88 billion (about a 2 percent increase) due to a 9 percent increase in I/M costs and a 57 percent increase in TCM costs. The increase results from more counties requiring programs since the number of counties unable to achieve the standard by 1987 increases from two under 9 ppm to approximately twelve under 7 ppm. Part of the reason the cost of the more stringent 7 ppm standard is only 2 percent greater than the 9 ppm standard is because the former has an initial date of 1984. Certain counties which might have needed I/M in 1982 to meet the 7 ppm are brought into attainment by FMVCP by 1984. These counties thus do not require I/M.

Under a 12 ppm standard, all counties are projected to attain the standard at a gross cost of $2.59 billion. The reduction in cost represents approximately a 8.2 percent savings relative to the current level. The largest component of the decrease in cost results from the change in net

TABLE 3-3

ANNUALIZED COSTS IN 1987 OF ATTAINING ALTERNATIVE CO STANDARDS, PRIMARY CASE[a/]

(1979 $\$10^6$)

Standard (ppm)	Number of Nonattainment Counties		Annualized Cost of FMVCP	Annualized Cost of I/M		Annualized Cost of TCM	Total Net Annual Cost	Total Gross Annual Cost
	Base Year[b/]	1987		Gross[c/]	Net			
7	119	12	\$2378	\$449	\$268	\$57	\$2703	\$2884
9	115	2	2378	411	246	36	2660	2825
12	44	0	2378	214	131	-4.7	2504	2587

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a/ Primary case assumes that the daily maximum form of the standard is chosen, the CO problem is confined to "hot spots" within the areas, MOBILE1 accurately models the effectiveness of I/M, and the tailpipe standard of 3.4 grams/mile is implemented in 1981 without waivers.

b/ Base year for 9 and 12 ppm standards is 1982 with 1984 used for the more stringent 7 ppm standard.

c/ Gross costs exclude fuel savings.

TCM cost. As shown in the table, TCM costs change to a net savings of $4.7 million from a cost of $36 million.

Only a few areas will need TCM and these tend to be localized in nature. These are for the most part the least expensive control measures whose costs are offset by fuel savings.

3.4 SENSITIVITY ANALYSES

As indicated in Section 3.3.1, several assumptions affecting cost were made for the primary case estimates. In order to examine the sensitivity of costs to analytical assumptions and the configuration of the standard, analyses were performed under alternative assumptions. The permutations of analytical variables are presented as Scenarios 1 through 9 in Table 3-4 (in addition to the base case). Tables 3-5 through 3-10 present the costs, percent change from the primary case, and number of remaining nonattainment counties under each scenario. Table 3-11 presents a summary of the costs calculated for each scenario. All of the costs are compared to the primary case scenario for that level of the standard.

The following sections discuss briefly which variables were altered as well as the rationale and the alternatives selected for sensitivity analyses.

3.4.1 I/M Effectiveness

One of the sensitivity concerns related to the estimation of control costs and effectiveness is that I/M programs imposed in cold areas (defined as average temperature below 50°F) will be less effective in reducing total emissions than presently modeled by MOBILE1. As temperature decreases, emissions during warmup of the vehicle increase, due at least in part to the inherently inefficient cold-start operation of engines; inadequate maintenance is responsible only in part and to an

TABLE 3-4

SENSITIVITY ANALYSIS SCENARIOS

Scenario	Averaging Time	Form of the Standard	Growth	I/M Effectiveness	Tailpipe Standard
Primary Case	8-hour	daily*	"hot spot"	100%	3.4
1	8-hour	daily	"hot spot"	50%	3.4
2	8-hour	daily	regional	100%	3.4
3	8-hour	2nd high	"hot spot"	100%	3.4
4	8-hour	2nd high	"hot spot"	50%	3.4
5	8-hour	2nd high	regional	100%	3.4
6	8-hour	2nd high	regional	50%	3.4
7	8-hour	daily	regional	50%	3.4
8	8-hour	statistical+	"hot spot"	100%	3.4
9	8-hour	statistical	"hot spot"	50%	3.4

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*The highest of the 24 possible overlapping eight-hour averages for a day is used in computing the expected number of exceedances.

+All of the possible overlapping eight-hour averages in a year are used in computing the expected number of exceedances.

TABLE 3-5

ANNUALIZED COST IN 1987 OF ATTAINING CURRENT AND ALTERNATIVE CO NAAQS, SCENARIO 1[a/]

(1979 $\$10^6$)

Standard (ppm)	Number of Nonattainment Counties		Annualized Cost of FMVCP	Annualized Cost of I/M		Annualized Cost of TCM	Total Net Annual Cost	Total Gross Annual Cost	% Δ from Primary Case
	Base Year[b/]	1987		Gross	Net				
7	119	22	$2378	$458	$273	$114	$2765	$2950	+2.2%
9	114	7	2378	410	245	47	2670	2835	+0.3
12	44	1	2378	225	132	2	2512	2605	+0.1

[a/] Eight-hour daily, hot spot, 50% effectiveness of I/M in areas with average temperature below 50°F.

[b/] 1982 for 9 and 12 ppm, 1984 for 7 ppm.

TABLE 3-6

ANNUALIZED COST IN 1987 OF ATTAINING CURRENT AND ALTERNATIVE CO NAAQS, SCENARIO 2[a/]

(1979 $\$10^6$)

Standard (ppm)	Number of Nonattainment Counties		Annualized Cost of FMVCP	Annualized Cost of I/M		Annualized Cost of TCM	Total Net Annual Cost	Total Gross Annual cost	% Δ from Primary Case
	Base Year[b/]	1987		Gross	Net				
7	144	41	$2378	$551	$333	$160	$2871	$3089	+7.1%
9	135	15	2378	458	293	84	4755	2920	+3.4
12	59	3	2378	284	173	47	2598	2709	+4.7

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a/ Eight-hour daily, regional growth, cold-start reductions modeled correctly.

b/ 1982 for 9 and 12 ppm, 1984 for 7 ppm.

TABLE 3-7

ANNUALIZED COST IN 1987 OF ATTAINING CURRENT AND ALTERNATIVE CO NAAQS, SCENARIOS 3, 4, 5, and 6[a/]

(1979 $\$10^6$)

Scenario	Number of Nonattainment Counties		Annualized Cost of FMVCP	Annualized Cost of I/M		Annualized Cost of TCM	Total Net Annual Cost	Total Gross Annual Cost	% Δ from Primary Case
	Base Year[b/]	1987		Gross	Net				
3[b/]	125	3	$2378	$507	$321	$35	$2734	$2920	+3.4%
4[c/]	125	7	2378	468	281	44	2703	2890	+2.3
5[d/]	143	16	2378	540	326	91	2795	3009	+6.5
6[e/]	143	28	2378	550	332	124	2834	3052	+8.0

[a/] All scenarios examine only the 9 ppm standard.

[b/] Eight-hour 2nd high, hot spot, cold-start reductions from I/M modeled correctly.

[c/] Eight-hour 2nd high, hot spot, cold-start reductions cut by 50% for counties below 50°F.

[d/] Eight-hour 2nd high, regional growth, cold-start reduction from I/M modeled correctly.

[e/] Eight-hour 2nd high, regional growth, cold-start reductions cut by 50% for counties below 50°F.

TABLE 3-8

ANNUALIZED COST IN 1987 OF ATTAINING CURRENT AND ALTERNATIVE CO NAAQS, SCENARIO 7[a]

(1979 $\$10^6$)

Standard (ppm)	Number of Nonattainment Counties		Annualized Cost of FMVCP	Annualized Cost of I/M		Annualized Cost of TCM	Total Net Annual Cost	Total Gross Annual Cost	% Δ from Prmary Case
	Base Year[b]	1987		Gross	Net				
7	114	54	$2378	$564	$340	$284	$3002	$3226	+11.86%
9	135	24	2378	489	295	115	2788	2982	+ 5.56
12	59	3	2378	298	179	47	2604	2723	+ 5.26

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[a] Eight-hour daily, regional growth, 50% I/M emission reductions in counties below 50°F.

TABLE 3-9

ANNUALIZED COST IN 1987 OF ATTAINING CURRENT AND ALTERNATIVE CO NAAQS, SCENARIO 8[a]

(1979 $$10^6$)

Standard (ppm)	Number of Nonattainment Counties		Annualized Cost of FMVCP	Annualized Cost of I/M		Annualized Cost of TCM	Total Net Annual Cost	Total Gross Annual Cost	% Δ from Primary Case
	Base Year[b]	1987		Gross	Net				
7	130	23	$2378	$534	$331	$124	$2833	$3036	+5.2%
9	126	6	2378	474	283	51	2712	2903	+2.8
12	61	1	2378	334	199	13	2590	2725	+5.3

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[a] Eight-hour statistical, hot spot, cold-start reductions modeled correctly.

TABLE 3-10

ANNUALIZED COST IN 1987 OF ATTAINING CURRENT AND ALTERNATIVE CO NAAQS, SCENARIO 9[a/]

(1979 $\$10^6$)

Standard (ppm)	Number of Nonattainment Counties		Annualized Cost of FMVCP	Annualized Cost of I/M		Annualized Cost of TCM	Total Net Annual Cost	Total Gross Annual Cost	% Δ from Primary Case
	Base Year[b/]	1987		Gross	Net				
7	130	23	$2378	$677	$326	$248	$2952	$3303	+14.5%
9	126	11	2378	484	289	37	2704	2899	+ 2.6
12	61	2	2378	334	199	12	2589	2724	+ 5.3

[a/] Eight-hour statistical, hot spot, 50% I/M reductions in counties below 50°F.

TABLE 3-11

ANNUALIZED COST IN 1987 OF ATTAINING CURRENT AND ALTERNATIVE CO STANDARDS INCREASED DESIGN VALUES[a/]

(1979 $$10^6$)

Standard (ppm)	No. of Counties Base Year	No. of Counties 1987	Annualized FMVCP	Annualized Cost of I/M Gross	Annualized Cost of I/M Net	Annualized Cost of ICM	Total Net Annualized Cost	Total Gross Annual Cost	% Δ from Primary Case
9 Daily	152	9	$2378	$528	$315	$112	$2805	$3018	+6.8%
7 Daily	157	32	2378	562	335	240	2953	3180	+10.3
12 Daily	90	1	2378	376	214	-24	2568	2730	+5.5
9 2nd High	154	13	2378	545	326	137	2841	3060	+8.3

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a/ "Hot spot," cold start reduction modeled correctly.

unknown extent. As a result, the overall emissions in cold areas may not be reducible due to I/M to the extent assumed in MOBILE1.

To account for possible lower effectiveness at low temperatures, I/M programs in areas with below 50°F average temperatures were credited with only 50 percent of the otherwise expected reductions in MOBILE1. Table 3-5 presents these costs for the 9 ppm standard (daily high) using the 50 percent I/M effectiveness assumption.

The reduction in program effectiveness increases the cost of attainment as well as the number of nonattainment counties. The lack of complete I/M effectiveness means that additional emission reduction will be required through more stringent I/M programs and increased use of TCM controls. The total gross cost of all mobile source control including FMVCP increases by less than one percent. For each county, the net cost increase of I/M using a 30 percent stringency level compared to a 20 percent stringency level is not significant; while greater repair costs result from the 30 percent stringency level, greater fuel savings also occur. Virtually all of the cost increase is incurred in TCM costs. The primary effect of "cold start" assumptions is on the ability of counties to attain the standard, not on cost (although there are increases), as an additional five areas may not be able to meet the standard.

3.4.2 VMT and Area Source Growth Rate

The second area of sensitivity analysis involves the rate of growth in VMT and area source emissions. A scenario was considered in which growth in emissions is based on a regional area-wide estimate, using the Bureau of Economic Analysis (Department of Commerce) projections and VMT projection from the Federal Highway Administration. Since these statistics tend to be based on higher estimates of growth, this scenario generally requires greater emission reductions. Table 3-6 presents the cost estimates using these growth rates and compares the cost to the primary case.

The nature of the primary case "hot spot" analysis indicates that the CO problem exists primarily in high density portions of the particular areas, thus precluding large amounts of growth around that hot spot. Recent evidence indicates that in some areas the CO problem may be more area-wide than previously believed in that high readings of CO values may result from emissions from a broader area than just the localized central business district. The alternative scenario treats the CO attainment problem from this area-wide perspective and uses regional growth predictions to estimate growth in emissions. In addition to the increase in future emissions, the regional growth scenario includes 100 percent of the area emissions in the effective emissions. This compares with 20 percent of area emissions included under the primary case scenario.

The regional growth scenario has a marked effect since both future emissions and needed reductions are increased. The total gross cost of control for a 9 ppm daily standard increases by about 3 percent -- more than $80 million. It is, in fact, a larger increase in cost than the alternative 7 ppm standard under primary case assumptions. The most significant area of cost increase is in TCM where the increase is close to $50 million or 133 percent. This occurs since more counties are unable to meet the standard with I/M alone. The increase in I/M costs is $35 million or 17 percent.

Fifteen counties may not achieve the current standard even with TCM under the regional growth projections, whereas only two counties were potentially in nonattainment under the low growth scenario.

3.4.3 Form of the NAAQS

Another area of sensitivity analysis considers the form of the standard, that is, the method by which the design value is calculated and attainment is determined. Recall that the design value serves as the basis for determining the needed rollback in emissions. In addition to the daily maximum, EPA has evaluated the impact of alternative forms of the standard as discussed in Section 3.1.2. Tables 3-7 and 3-9 present the costs of attainment for both variants of the standard and compare them to the daily form.

Comparing the cost for the different forms of the standard to the primary case indicates the increased stringency of the mobile source control required under each alternative. Relative to the 9 ppm daily standard, the total gross costs are about 2.8 percent and 3.4 percent higher for the 9 ppm statistical and second-high, respectively. Again, the majority of the increase results from greater amounts of TCM required.

Up to six counties may not be able to attain the hourly interpretation of the statistical form of the 9 ppm standard, compared to three counties under the daily interpretation. There is no difference between the number of counties not meeting the second-high standard and the daily standard, since the change in design values is not enough to change any county's ability to attain the 9 ppm level.

3.4.4 Design Values

As indicated previously, the design values used in this analysis were obtained from a review of CO ambient air quality data in EPA's SAROAD data base, which represents the only readily available source of consistent data for all of the areas investigated. Sufficient data are contained in the data base to estimate the approximate values based on the alternative forms of the standard.

The emission reductions needed in any county are extremely sensitive to the design value, since a change in the design value changes the emission-to-air quality relationship used to determine the allowable emissions. There is some concern that design values as registered by the monitoring system (see Section 3.1.2) may not represent the true air quality readings actually present in the county or those values which will be used in the actual State planning process; many monitor locations do not meet EPA's siting criteria and thus are not recording proper values. Monitoring data were obtained from SAROAD in four cities -- Phoenix, San Jose, Seattle, and Chicago -- with data gathered independently for EPA by a private contractor (Jordon, 1979). A comparison shows that there are certain differences between the SAROAD data and on-street monitor readings. The independent data were gathered for an eight-day period at each site and then compared to SAROAD data used to determine the design values in this study. The result was generally that at least one of the independent monitoring sites recorded higher values than corresponding SAROAD data. The data from Chicago were the major exception.

Based on the results of the above analysis and on a comparison of SAROAD values with values generated by EPA's Regional Offices, there may be some inaccurate values in the SAROAD data base. In order to account for this suspected discrepancy, a sensitivity analysis has been conducted whereby the design values are adjusted by increasing the SAROAD value by 20 percent. Such an increase will account for the maximum possible impact of potential design value underestimations.

Table 3-11 presents the cost of CO control under the increased design values. These costs are generated assuming a one percent growth of VMT and area emissions and complete effectiveness of I/M emission reductions.

3.4.5 Combined Sensitivity

The effect on the cost of a single change in the assumptions can be estimated by the changes already noted (Sections 3.4.1 to 3.4.3). For instance, regardless of other assumptions, the hourly interpretation of the statistical standard will be more costly and more difficult to attain than the daily interpretation. Likewise, reducing the effectiveness of I/M in cold areas or increasing the VMT growth projections increases the cost and reduces the expected success of the overall programs. The combined scenarios illustrate the relative strength of each variable, in terms of a net impact, and the result of their combined effect.

3.5 INCREMENTAL COSTS OF CO CONTROL*

Costs presented in previous sections represent the portion of the costs allocated to CO control as opposed to the total costs of the programs. Tailpipe emission control systems as well as in-use programs such as I/M provide for the simultaneous control of more than one pollutant. Thus, the most accurate indication of the costs of programs for CO control is obtained from this equal allocation of costs among multi-pollutant programs.

Nonetheless, presentation of the incremental costs of CO control is also informative from the standpoint of those costs resulting directly from setting the ambient air quality standard. In this case, the costs of programs or portions of programs where CO control is the sole emphasis are isolated. Programs which are being implemented for the control of other pollutants and which would be required regardless of the need for CO control are not considered. The following discussion presents the incremental costs for controlling CO through the FMVCP as well as through the I/M and TCM programs.

3.5.1 Incremental Costs of FMVCP

Estimating the costs of controlling CO only through the FMVCP is exceedingly difficult. Since control of CO, HC, and NO_x has been mandated simultaneously, all estimates present costs for systems which control all three pollutants. Little attention has been given to the situation of assessing the configuration and costs of control systems given the premise that control of CO is not required. As a result of the lack of pertinent data, the assumption is made that the three-way catalyst would be used in future technology cars (1981 and later) even without the CO control requirements.

However, the inclusion of the oxidation catalyst in combination with the three-way catalyst can be attributed solely to the requirement of controlling CO to the statutory limit of 3.4 grams/mile. Hence, the incremental costs of CO control resulting from the FMVCP can be viewed as the costs of requiring oxidation catalysts on future technology cars. Based on information from auto manufacturers as well as independent sources, EPA estimates that the cost of adding an oxidation clean-up catalyst to a three-way catalytic converter ranges from $14 to $40 per auto. Using the approach outlined in Appendix A (Table A-2) for determining the annualized hardware costs, the fleet-wide annualized costs will range from $200 million to $600 million in 1987. This takes into account hardware costs only and does not assume any maintenance or fuel benefits or penalties associated with the oxidation catalyst.

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*This section deals in a partial sense with reversibility of control costs associated with systems designed to reduce HC and NO_x emissions, as well as CO emissions. It is not meant to describe total incremental costs for the alternative standards.

3.5.2 Incremental Costs of I/M and TCM

While the majority of areas that will be implementing I/M programs experience both ozone and CO problems and thus need control of both HC and CO, several areas have just a CO problem. While these areas also receive benefits of HC control from I/M programs, the programs are instituted primarily because of the need for CO control. As a result, the incremental costs of I/M for CO control represent the costs of programs in these areas. These areas include those with current plans to institute programs in 1982 that are designated as nonattainment for CO only, as well as the areas identified in this analysis as possibly needing I/M programs for CO in the future but which are not currently designated nonattainment.

Using this approach for determining the incremental CO control requirements, 50 areas could need I/M programs for CO only under a 9 ppm daily standard (primary case assumptions). The gross costs are estimated to be around $120 million while the net costs, assuming fuel economy benefits, will be close to $70 million. Under a 12 ppm standard, 14 areas could require I/M, with the incremental cost ranging from $15 to $30 million annually. While the number of areas requiring I/M only increases to 53 under a 7 ppm standard, many of the areas will require more stringent programs than with the other standards. The gross cost of I/M would be about $145 million while the net cost would be around $80 million. These results are summarized in Table 3-12.

The incremental cost of TCM for CO cannot be estimated readily because of the variability of the effectiveness of similar strategies for HC and CO. An area-wide program implemented to combat an ozone problem may not necessarily alleviate an area's CO problem, particularly if the problem area is a hot spot. Moreover, meaningful conclusions cannot be drawn concerning the incremental costs of TCM in areas for CO control alone. Thus, the aspects of TCM costs are ignored in this analysis of incremental costs.

TABLE 3-12

INCREMENTAL ANNUALIZED COSTS IN 1987 OF ATTAINING ALTERNATIVE CO STANDARDS[a/]

($1979 10^6)

Standard (ppm)	Number of Areas Implementing I/M for CO only	Incremental Annualized Costs of I/M[b/]		Incremental Annualized Costs of FMVCP[c/]	Total Incremental Annualized Costs[d/]
		Gross	Net		
7	53	145	$80	$200-600	$345-745
9	50	120	70	200-600	320-720
12	14	30	15	200-600	230-630

[a/] Based on primary case assumptions, which are outlined in Table 3-3.

[b/] Incremental costs of I/M pertain only to those areas needing I/M for CO control only. Net costs assume a fuel economy benefit.

[c/] Incremental costs of FMVCP include costs of adding oxidation clean-up catalyst on post-1980 cars in order to meet 3.4 gm/mi standard.

[d/] Total costs are sum of gross I/M costs and FMVCP costs.

REFERENCES FOR SECTION 3

Jordon, Bruce C., Environmental Protection Specialist. 1979. Memorandum to Ken Lloyd, Economic Analysis Branch, EPA. "Comparison of CO Data from SRI 'Hotspot' Study to Data in SAROAD."

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4. STATIONARY POINT SOURCE CONTROL

This section presents the costs of stationary point source control requirements to meet the current and alternative CO ambient air quality standards. The sources were examined in isolation, using an assumed background CO level of 2ppm; the control requirements and costs were selected to meet the ambient standard at the lowest annualized cost of control including any steam credit obtained from burning CO (PEDCo, 1979). Since these sources were examined based on projected maximum impact, there is no difference in cost between different forms of the standard.

A complete description of the methodology used and assumptions made in this simulation is presented in Appendix B.

4.1 STATIONARY POINT SOURCE COSTS

Tables 4-1 and 4-2 present the results of the modeling and costing procedures (the method for making these calculations is presented in Appendix B). Capital costs (Table 4-1) and annualized costs (Table 4-2) are presented for alternative eight-hour standards by industry. Each table also indicates the number of facilities which require control under any alternative.

Costs are presented in 1979 dollars and reflect the total initial capital cost and the annualized cost for a 1987 attainment date. It should be noted that the results shown here are applicable to attainment dates prior to 1987 due to the exclusion of growth (see Appendix B.4) and retirement. The latter would tend to reduce costs for existing sources as it would deplete the existing source inventory to some degree between 1979 and 1987. Lacking information on equipment age, the assumption was made that the equipment population would remain static, that is, retirement of obsolete equipment would not occur during the period of concern.

TABLE 4-1

CAPITAL COSTS FOR STATIONARY POINT SOURCES, BY INDUSTRY: EIGHT-HOUR ALTERNATIVE CO STANDARDS

(1979 $\$10^3$)

		Number of Controlled Sources			Capital Costs of CO Control		
SIC	Industry	7 ppm	9 ppm	12 ppm	7 ppm	9 ppm	12 ppm
2865	Maleic anhydride	3	2	2	$ 1,900	$ 1,140	$ 1,770
2895	Carbon black	12	11	6	26,630	23,650	13,610
3312	Steelmaking	2	1	1	21,400	4,400	4,900
3321	Gray iron	18	12	4	281	170	54
3334	Primary aluminum	2	2	2	32,000	32,000	32,000
3711	Automobile manufacturing	1	0	0	19	0	0
4953	Incineration	1	1	1	5	5	5
TOTAL[a/]		39	29	16	$82,235	$61,365	$52,339

[a/] Figures may not sum due to rounding.

TABLE 4-2

ANNUALIZED COSTS FOR STATIONARY POINT SOURCES, BY INDUSTRY:
EIGHT-HOUR ALTERNATIVE CO STANDARDS
(1979 $$10^3$)

		Number of Controlled Sources			Capital Costs of CO Control		
SIC	Industry	7 ppm	9 ppm	12 ppm	7 ppm	9 ppm	12 ppm
2865	Maleic anhydride	3	2	2	-$404	-$164	-$1,380
2895	Carbon black	12	11	6	-13,336	-12,010	-6,471
3312	Steelmaking	2	1	1	-9,230	-230	-2,300
3321	Gray iron	18	12	4	412	297	81
3334	Primary aluminum	2	2	2	32,000	32,000	32,000
3711	Automobile manufacturing	1	0	0	67	0	0
4953	Incineration	1	1	1	5	5	5
TOTAL[a/]		39	29	16	$9,514	$14,898	$21,935

[a/] Figures may not sum due to rounding.

4.1.1 Attainment of Current Eight-Hour Standards

4.1.1.1 Costs

Attainment of the eight-hour 9 ppm standard results in a capital expenditure of almost $331 million (see Table 4-1) and an annualized cost of $9.9 million (see Table 4-2). Three industries incur positive annualized costs: primary aluminum amounts to $32.0 million, followed by gray iron with $297,000, and incineration with $5,000. The bulk of the negative annualized cost stems from carbon black, which accounts for $13.3 million in annualized savings. Steel incurs an annualized cost of -$230,000 and maleic anhydride shows -$164,000.

4.1.1.2 Tonnage Reduction

Table 4-3 shows the degree of CO emission reduction under alternative eight-hour standards. The eight-hour 9 ppm standard results in 964,100 tons of reduction, over 75 percent of which is produced by the carbon black industry. Steel accounts for 9 percent of the reduction; gray iron represents 8.5 percent of the reduction (82,000 tons); and primary aluminum accounts for 4.4 percent (42,000 tons).

4.1.2 Attainment of Alternative Eight-Hour Standards

4.1.2.1 Costs

The capital cost required by industry under the alternative eight-hour standards (Table 4-1) indicates that a 34 percent increase is caused by the 7 ppm alternative. The most significant increases under 7 ppm occur for maleic anhydride (67 percent), steelmaking (386 percent), and gray iron (65 percent). The 7 ppm standard shows a positive annualized cost (Table 4-2) for four industries: gray iron, primary aluminum, automobile manufacturing, and incinerators. The largest increase in cost occurs in the gray iron industry. This happens since 50 percent more sources must control than under the current standard.

TABLE 4-3

TONS OF CO REDUCTION, BY INDUSTRY: EIGHT-HOUR ALTERNATIVE CO STANDARDS
(10^3 tons)

SIC (NEDS)	Industry	Eight-Hour Alternative CO Standard		
		7 ppm	9 ppm	12 ppm
2865	Maleic anhydride	29.8	21.8	15.8
2895	Carbon black	853.9	729.0	443.0
3312	Steelmaking	157.0	88.0	19.0
3321	Gray iron	105.9	82.3	17.6
3334	Primary aluminum	42.0	42.0	42.0
3711	Automobile manufacturing	16.0	0.0	0.0
4953	Incineration	1.0	1.0	1.0
TOTAL		1208.6	964.1	538.4

Three industries--maleic anhydride, carbon black, and steelmaking--provide negative annualized costs sufficient to reduce the annual cost to $9.5 million compared to the $19.9 million under the current standard.

Under a relaxed alternative eight-hour standard (i.e., 12ppm), the total capital expenditure decreases by 14.7 percent. Relaxation of the standard for both maleic anhydride and steelmaking under the 12 ppm standard decreases the capital expenditure. This happens because the control strategies which may be used to comply with a 12 ppm standard provide a greater benefit in terms of lower annualized costs. This control strategy removes less CO, however (see Table 4-3), and therefore could not be used for the 7 or 9 ppm standards.

Three industries show positive annualized cost for the 12 ppm standard: primary aluminum, gray iron, and incinerators. Under the 12 ppm standard, however, the total annualized cost increases by 10 percent. Again, this happens because the reduced stringency eliminates some control on carbon black which provided a net savings of $5.5 million.

4.1.2.2 Tonnage Reduction

The reduction in CO emissions attributable to the alternative standards is shown in Table 4-3. The 7 ppm alternative results in a 25 percent incremental reduction over the current standard. This alternative represents the most restrictive concentration level of any standard as indicated by the level of CO reduction achieved in response.

The less stringent alternative reduces emissions by 538,400 tons from current levels and represents a 44.2 percent decrease from the reduction required to attain current standards.

REFERENCES FOR SECTION 4

Pedco Environmental, Inc. (PEDCo). February 1979. "Control Techniques and Costs for Carbon Monoxide Emissions -- Interim Report #1."

5. MOBILE SOURCE ECONOMIC ANALYSIS

5.1 INTRODUCTION

The mobile source control costs presented in Section 3 consist of obligations to be paid by local governments or by individual car owners. The impact of these costs is analyzed in terms of their effect on these two sectors.

Five scenarios were chosen for economic analysis. They include the three levels (7, 9, and 12 ppm) of the eight-hour daily standard under the primary case assumptions, the 9 ppm daily standard assuming regional growth of VMT and area source emissions, and the 9 ppm second-high standard with primary case assumptions. Separate economic analyses were not performed on any of the cases assuming reduced I/M effectiveness because there was little difference in the costs between the 50 percent effectiveness and the 100 percent effectiveness cases.

It was assumed that the payments made by local government, primarily for initial investment of I/M and gross annual TCM costs, are paid directly from local government revenues. The relative ease or difficulty in paying the cost depends on the revenue received. The costs therefore are compared to typical government revenues for the localities involved.

The costs paid by individual car owners, which include FMVCP, inspection, and I/M repairs, were calculated from average cost estimates. The impact of these costs on average individuals would be difficult to specify. In addition, the variance of costs around the average estimates is not known and could be more significant than the averages themselves.

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*It should be noted that because of the user charge, or fee, that the I/M program, once developed, is self-supporting.

Examination of costs borne by motorists may be more useful if performed across income levels, that is, by determining the relative burden on different economic classes of motorists. The fuel savings provided by I/M programs and TCM are examined in the same manner. Fuel savings can help reduce the net cost of the control programs to groups of motorists, but they are received by this portion of the population only and cannot be transferred to cover other costs. The lack of liquidity of costs and savings makes the economic analysis not only a question of direct and indirect impacts, but also one of the progressive or regressive nature of costs. In other words, is the cost being paid by those individuals best able to pay, or is a disproportionate amount of the cost paid by lower income groups?*

5.2 ANALYTICAL PROCEDURE AND ASSUMPTIONS

5.2.1 Federal Motor Vehicle Control Program

Regardless of the ambient air quality standard level, the cost of FMVCP must be paid. FMVCP, while separate from the National Ambient Air Quality Standards (NAAQS) program, provides emission reductions necessary to attain a standard. In the absence of FMVCP, emission reductions provided by the program in a nonattainment area would have to be obtained through additional control measures.

The cost of the program (see Appendix A) is derived through control of five sectors: heavy-duty vehicles, light-duty vehicles, light-duty trucks, motorcycles, and aircraft. Over 80 percent of total annual cost of the program results from control of light-duty vehicles, light-duty trucks, and motorcycles. It is assumed that costs from these sectors are borne by the owners of these vehicles. The costs then, can be divided by income group using automobile ownership information obtained from the Department of Transportation (DOT, 1974). It is assumed that ownership patterns for light-duty trucks and motorcycles are similar to those of light-duty vehicles.

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*It should be stressed that this analysis ignores benefits of control accruing to all income groups; thus, it is unfair to just focus on cost burdens to different income groups. Even if the control requirements are regressive on net, they are consistent with the "polluter pays" principle.

The cost of FMVCP for heavy-duty vehicles and aircraft comprises less than 20 percent of the cost of the program. It is assumed that most heavy-duty vehicles and aircraft are used in industry or for commercial purposes. Because these costs are imposed on all heavy-duty vehicles and aircraft, the cost of control can be passed through to the final consumer. The magnitude of these costs, $431.1 million for all heavy-duty vehicles and $41 million for all aircraft, indicates that pass-through of costs would have virtually no measurable effect on the prices of the goods and services involved.

5.2.2 Inspection/Maintenance Program

5.2.2.1 Initial Capital Investment

The estimate of initial capital required to start an I/M program is dependent solely upon the number of cars inspected under the program. An average figure of $13.21/car generates the cost.

It is assumed that initial expenditure is made by the county government. Problems in budgeting and allocating the county funds are not considered in this analysis; instead, the initial investment is compared to total county revenues including transfers from Federal and State sources. Since both the cost and the governmental revenues depend on the population of the county, the analysis presents the data separately for urbanized counties and other counties.

Recall from Section 3 that I/M programs implemented in one county of an urbanized area must be extended to all counties within the area. Since governmental revenue data are not available by urbanized area, a factor must be added to account for multiple-county urbanized areas.

In this analysis, urbanized areas, as defined here, are separated into two groups: large urbanized areas containing multiple counties, and individual counties that are not part of the larger urbanized area. The maximum adverse impact would occur if there were only two counties in each area, since the cost would be divided by the minimum number of revenue sources. Initial investments within urbanized areas are examined in this manner. The average investment cost per urbanized area is divided by two and then calculated as a percentage of large county total revenue.

The investment costs in other counties are compared to a range of revenues for counties across the country. This provides an indicator showing any difficulties in meeting the capital requirements of the program at the extremes of county income levels.

5.2.2.2 Inspection Costs

Under an I/M program, all registered passenger vehicles would be inspected each year. A fee of $7.00 per vehicle is estimated to be the annualized cost of the inspection. This fee is designed to cover the capital costs and operating expenses of the inspection and would be paid by the owner of the car.

The total inspection cost, therefore, can be divided into the income groups of car owners who pay for the inspection. The Department of Transportation statistics again are used to accomplish this. The resulting distribution of cost by income group is examined to determine where the burden of cost is heaviest. It already is known that the average car owner pays $7.00, but this distribution does not tell what, if any, redistributive effect results from the program.

5.2.2.3 Repair Costs

Any automobile failing the inspection test is required to undergo maintenance, with the cost of repairs estimated at $28 per vehicle. Each State, in its State Implementation Plan (SIP) for attainment, will determine the test criteria for passing and failing the test. A given stringency factor (i.e., number of failures) can result in several emissions criteria for failure. For each State, test thresholds could be different.

Historically, even with this variation, there is a correlation between the age of the vehicle and failure rate. Data regarding this correlation were published by the Air Pollution Control Association (APCA, 1979). Using these data, a statistic indicating likelihood of failure by age was created. The probability of failure was divided by the probability of failure of a car of mean age (DOT, 1974). This age-failure index is presented in Table 5-1. The statistic then can be applied to any stringency factor to determine the increased or decreased probability of failure as a function of age.

A distribution of age of car by income of the owner was found in the National Personal Transportation Study (DOT, 1974). These data are presented in Table 5-2. For each income level and corresponding mean age of car, the table also shows the age-failure index, which is calculated by linear interpolation between years.

A distribution of repair costs is determined from these statistics by multiplying income group ownership by the corresponding age-failure index. The resulting distribution is normalized by dividing by the summation of the age-failure index times the percent of cars by income in order to indicate a distribution of cost. In functional form, the statistic is calculated as follows:

TABLE 5-1

AGE-FAILURE INDEX

Year	Observed Failures (percent)	Index Observed ÷ Mean
1	55%	0.085
2	49	0.745
3	60	0.911
4	69	1.049
5	70	1.063
6 and above	71	1.079
Mean	65.8%	1.000

TABLE 5-2

DISTRIBUTION OF MOBILE SOURCE COST FACTORS

Income Level	Age	Age-Failure Index	Percent of Cars	Age X Percent	Distribution by Income
<$4800	7.0	1.079	5.91%	0.0637689	0.05989890
4800-6400	6.1	1.079	4.74	0.0511446	0.04804900
6400-8000	6.2	1.079	4.68	0.0504972	0.04743280
8000-9600	6.0	1.079	7.40	0.0798460	0.07500060
9600-12,100	5.6	1.073	12.60	0.1351980	0.12699360
12,100-16,000	4.8	1.060	18.02	0.1910120	0.17942059
16,000-24,100	4.6	1.057	24.53	0.2592821	0.24354777
>24,100	4.0	1.049	12.50	0.1311250	0.12316778
Unreported	5.5	1.069	9.61	0.1027309	0.09649676

$$\frac{IG \times AF}{*(IG \times AF)}$$

where

IG = Percentage of cars by income group

AF = Age-failure index

* = Summation over all income groups.

Each factor is presented in Table 5-2.

It should be noted that implicit within this calculation is the assumption that the mean failure rate of a car whose owner is part of a particular income group can be estimated by the failure rate of a car of mean age within that group. Strictly, this would be true only if the age distribution within each income group were normal. The resulting distribution therefore provides only an indicator of the burden of cost.

The normal distribution of repair cost is multiplied by the total repair cost for each scenario to indicate the relative burden of repair cost by income group.

5.2.2.4 I/M Fuel Savings

The fuel savings accrued by I/M programs are a direct result of the maintenance performed on vehicles that fail the emission test. The fuel savings benefit is received only by car owners that pay repair costs. The value of fuel savings can be divided using the same statistic created for the distribution of repair costs presented in the preceding section. The money saved by reduced fuel consumption is subtracted directly from the repair costs since the costs and savings are not independent.

5.2.3 Transportation Control Measures

5.2.3.1 Gross Annual Cost

The annual cost of TCM is assumed to be paid by the local county government (there is no direct charge to the motorist) and is treated as if it were paid by general county revenue. Since this is an annual cost, the revenue must meet the cost each year. The county cannot issue bonds or assume a loan and still remain solvent. It is possible that some portion of the cost could be paid by state or federal funds. Placement of the burden on the counties estimates the maximum possible impact for each county requiring TCM.

The average cost of control per county is compared to a range of county revenues obtained from the 1972 Census of Governments (Bureau of Census). The revenues were inflated to 1979 dollars using Federal Reserve Bank GNP deflators. This provides an indicator of the ability of a county to meet the obligation imposed by TCM annual costs.

5.2.3.2 TCM Fuel Savings

Fuel savings result from TCM by reducing the number of miles or hours traveled (see Section 3). The reduction in gasoline consumption is assumed to be constant per ton of CO reduced by TCM (see Section 4). This corresponds directly to the reduction in VMT. The fuel savings therefore are divided equally among all drivers on the basis of current VMT.

The National Personal Transportation Study (DOT, 1974) also provides data on the percent of total VMT traveled by each income group. Multiplying these percentages by the total value of TCM fuel savings under each scenario gives an estimate of the benefits of fuel savings to each income group.

5.3 ECONOMIC IMPACTS

5.3.1 Federal Motor Vehicle Control Program

Table 5-3 shows the annual cost of FMVCP, with the total cost for passenger cars, light-duty trucks, and motorcycles equaling $1.9 billion. Table 5-4 shows the distribution of these costs by income group.

The distribution indicates that the largest portion of the cost is felt by the $16,000-$24,000 income group. This group owns approximately 1.6 cars per household and pays 24.7 percent of the total cost or $470 million. The smallest portion of the cost is paid by the $6,400-$8,000 income group which pays only 4.7 percent of the total cost or $90 million.

The number of cars per household increases with income as illustrated in Figure 5-1. Once the $4800 mean level is reached, the marginal increase in number of cars per increased dollar in income diminishes at higher incomes. This can be seen from the distance between the midpoint of the distribution and the broken line. Therefore, in proportion to the income, a low income household will face a larger burden from FMVCP than will a high income family. This does not imply that the total burden on the low income group is disproportionate to its segment of the population. In 1979, approximately 12.8 percent of all households earned less than $6400 per year. By comparison, the same group pays only 10.6 percent of the total FMVCP. The result, therefore, indicates that there is no real additional burden to low income households as a group, although individual households within the low income group pay a substantially higher portion of their income for FMVCP than do individuals from higher income households.

This impact is present with all other scenarios discussed. The cost distribution by income group presented will serve as a basis for comparison with the costs of the other control techniques.

TABLE 5-3

TOTAL ANNUAL COST OF THE FMVCP IN 1987
(1979 $\$10^6$)

Type of Vehicle	Annual Cost of CO Control
Passenger Cars (LDV)	
Hardware	$2003
Fuel economy	(1710)[a/]
Unleaded gasoline cost	733
Operating and maintenance	(639.0)[a/]
Altitude controls	278
TOTAL	665
Light-Duty Trucks (LDT)	
Hardware	740
Fuel economy	0
Unleaded gasoline cost	354
Operating and maintenance	0
Altitude controls	100
TOTAL	1194
Heavy-Duty Vehicles (HDV)	
All costs	431
Motorcycles	
All costs	46
Aircraft	
All costs	42
TOTAL	$2378

[a/] Negative costs.

TABLE 5-4

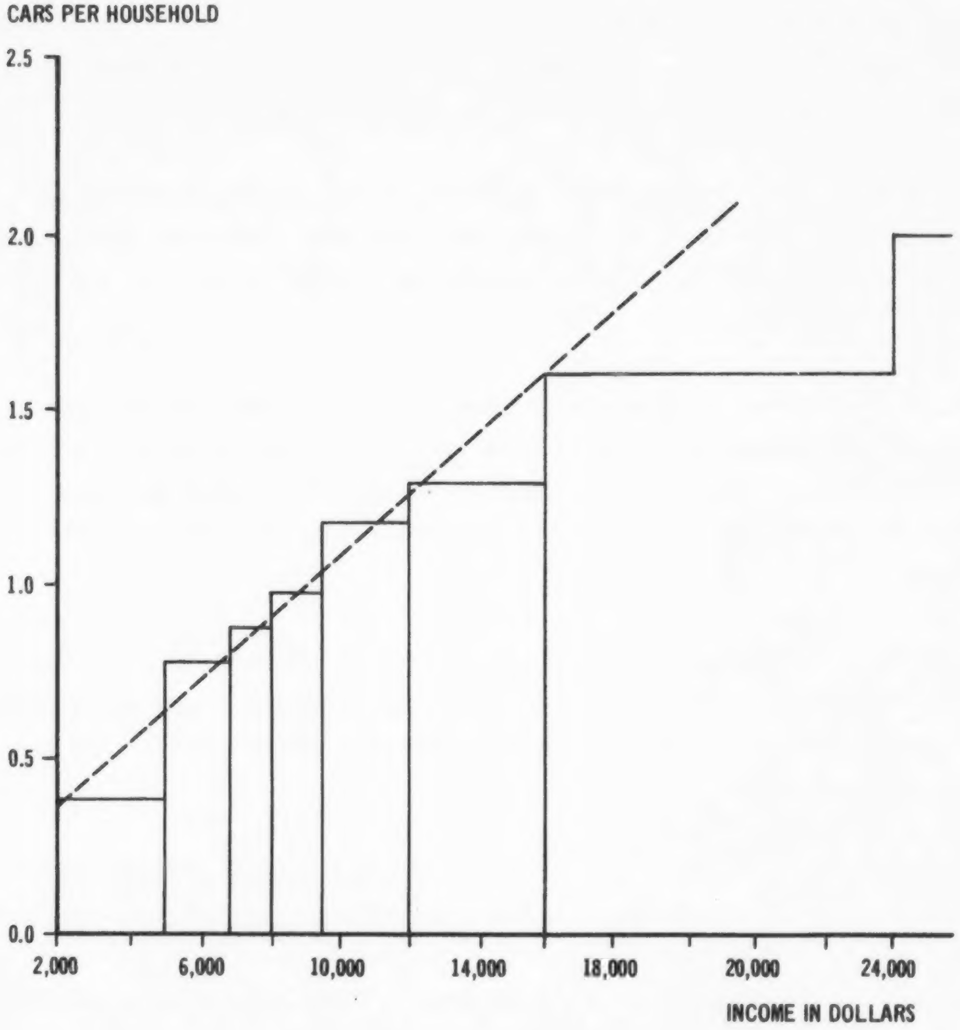
DISTRIBUTION OF FMVCP COSTS[a/] BY INCOME

Income Group	Percent of Cars	Average Number of Autos Per Household	FMVCP Costs ($\$10^6$)
<$4800	5.91%	0.4	$113
4800 - 6400	4.74	0.8	90
6400 - 8000	4.68	0.9	90
8000 - 9600	7.40	1.0	142
9600 - 12,100	12.60	1.2	241
12,100 - 16,000	18.02	1.3	345
16,000 - 24,100	24.53	1.6	470
>24,000	12.50	1.9	240
Unreported	9.61	1.2[1b/]	174
TOTAL			$1905

[a/] Costs for LDV's, LDT's and motorcycles

[b/] Mean number of autos per household

FIGURE 5-1
CARS PER HOUSEHOLD VS. INCOME



5.3.2 Inspection/Maintenance Program

5.3.2.1 Initial Investment Cost

Table 5-5 presents the initial investment cost in the five scenarios for which economic analysis is being performed. There is relatively little fluctuation in the average investment costs between scenarios.

The range of average investment costs for urbanized areas runs from $8.61 to $9.52 million. Recalling that each urbanized area contains at least two counties, the average investment cost per county is between $4.3 and $4.76 million.

The 1972 Census of Governments indicates that for counties with populations of 100,000 or more, the average revenue is $354.4 million per year in 1979 dollars. Hence, the range of initial investments per county in urbanized areas represents between 1.2 and 1.3 percent of the county revenue.

The initial investment costs for other counties range from $1.96 million to $2.41 million. The most expensive scenario is the 9 ppm daily standard assuming regional growth. The least expensive case is the 12 ppm level primary case.

The Census of Governments also provides average revenue figures for counties ranging in size from 10,000 to 25,000 or more people. Small counties on average receive $9.29 million per year in 1979 dollars. The average for all counties is $51.4 million. While a $2 million expenditure (average for the 9 ppm primary case) represents less than 3.9 percent of the average county revenue, it conceivably could consume 21.6 percent of the county revenue if the cost were borne by a small county. A county in this predicament would require either additional revenue or a reduction in services. To the extent that urbanized areas contain more than one county, these cost estimates tend to overestimate the impact on individual counties.

TABLE 5-5

INITIAL INVESTMENT COST
(1979 $\$10^6$)

Initial Investment Cost	Primary Case 7 ppm	Primary Case 9 ppm	Primary Case 12 ppm	9 ppm 2nd High Low Growth	9 ppm Daily Regional Growth
Urbanized area					
Total	$326.3	$297.4	$188.6	$314.9	$352.9
Average	9.32	9.59	11.8	9.00	8.61
Other counties					
Total	116.3	114.2	37.2	148.6	166.4
Average	2.00	2.00	1.96	2.36	2.41
TOTAL	$442.6	$411.6	$225.8	$463.5	$519.3

5.3.2.2 Inspection Cost

Table 5-6 presents the distribution of inspection costs by income group for the five scenarios under analysis. Since the distribution of cost is dependent upon the number of cars in each income group, the portion of the total inspection cost paid by each income group remains constant. Any fluctuation in cost of each inspection results from a change in the number of cars tested under the program.

As in the case of FMVCP, the inspection cost is regressive in nature. As income rises, there is a diminishing marginal increase in the number of cars owned by a household (see Figure 5-1); since the cost is directly proportional to the number of cars, the relative cost of inspection decreases for higher income levels. In simple terms, this indicates that a greater portion of the income of low income families is spent on inspection than that spent by higher income families.

This does not indicate that the proportional burden on the low income group as a whole is greater than their portion of the population. Approximately 12.8 percent of all households earn less than $6,400 per year while the same group pays only 10.6 percent of the total cost. The additional burden is placed on the individual low income household with a car.

5.3.2.3 Repair Costs

The repair costs of the I/M programs are divided by income group using the statistics created from the age-failure relationship (see Table 5-2). The results of these distributions of cost are presented in Table 5-7.

It should be remembered that the distribution of cost by income group represents a distribution based on historical failure rates. The actual distribution of the cost could differ from the estimates presented depending on the individual threshold values of emissions used to determine failure in each program.

TABLE 5-6

DISTRIBUTION OF INSPECTION COSTS
(1979 $\$10^6$)

Income Group	Primary Case 7 ppm	Primary Case 9 ppm	Primary Case 12 ppm	9 ppm 2nd High Low Growth	9 ppm Daily Regional Growth
<$4800	$13.9	$12.9	$7.1	$14.5	$14.7
4800-6400	11.1	10.3	5.7	11.4	11.8
6400-8000	11.0	10.2	5.6	11.2	11.7
8000-9600	17.4	16.1	8.8	18.2	18.4
9600-12,100	29.6	27.5	15.1	30.9	31.4
12,100-16,000	42.3	39.3	21.6	44.2	44.9
16,000-24,100	57.5	53.5	29.3	60.2	61.1
>24,100	29.3	27.3	14.9	30.7	31.1
Unreported	22.5	21.0	11.5	23.6	23.9
TOTAL	$234.5	$218.1	$119.6	$245.6	$249.1

TABLE 5-7

DISTRIBUTION OF I/M REPAIR COSTS (1979 $\$10^6$)

Income Group	Primary Case			9 ppm 2nd High Low Growth	9 ppm Daily Regional Growth
	7 ppm	9 ppm	12 ppm		
<$4800	$12.8	$11.6	$5.6	$12.9	$13.8
4800-6400	10.3	9.2	4.48	10.3	11.1
6400-8000	10.2	9.1	4.48	10.2	11.0
8000-9600	16.0	14.4	7.0	16.2	17.3
9600-12,100	27.1	24.5	11.9	27.2	29.4
12,100-16,000	38.5	34.6	16.8	38.6	41.4
16,000-24,100	52.1	47.04	22.8	52.4	56.4
>24,100	26.4	23.8	11.6	26.5	28.5
Unreported	20.6	18.7	9.1	20.8	22.3
TOTAL	$214.0	$193.0	$93.8	$215.1	$231.2

The effect of increased failure in the older cars tends to exacerbate the problems of the low income group. As Table 5-2 shows, the inclusion of the age-failure index causes the distribution of repair costs to be skewed towards low income groups compared to the original distribution of car ownership. The shift in distribution, while never more than 0.1 percent for any income group, adds to the adverse income distribution impact of the mobile source costs. Again, the total burden on the income group is not disproportionate; it is individual low income households that may by adversely affected.

Since the percentages calculated to distribute the repair costs are independent of the scenario, the relative impacts between income groups is the same for all five scenarios. The difference in absolute impacts is brought about by the increases or decreases in program stringency and number of counties in which programs are required.

5.2.3.4 Fuel Savings for I/M

The fuel savings for I/M are related directly to the repairs performed on vehicles that fail inspection. The fuel savings therefore can be distributed among income groups using the same percentages used to distribute the repair costs; Table 5-8 presents the results of this distribution of fuel savings.

Since the fuel savings occur directly from maintenance, the value of these savings can be subtracted directly from the repair cost to estimate a total of repair. In all cases, the amount of fuel savings for each income group exceeds the corresponding repair cost. The total annual impact of repairs including fuel savings is a net savings. Table 5-9 presents these net savings for each income group.

The statistical nature of the repair cost and the fuel savings (i.e., using the average costs for each without a distribution of costs) makes

TABLE 5-8

DISTRIBUTION OF FUEL SAVINGS FROM I/M
(1979 $\$10^6$)

Income Group	Primary Case			9 ppm 2nd High Low Growth	9 ppm Daily Regional Growth
	7 ppm	9 ppm	12 ppm		
<$4800	$10.8	$9.9	$6.2	$11.1	$11.5
4800-6400	8.6	7.9	5.0	8.9	9.3
6400-8000	8.5	7.8	4.9	8.8	9.1
8000-9600	13.5	12.4	7.8	13.9	14.5
9600-12,100	22.9	21.0	13.2	23.5	24.5
12,100-16,000	32.3	29.6	18.7	33.2	34.6
16,000-24,100	43.8	40.2	25.3	45.1	46.9
>24,100	22.2	20.3	12.8	22.8	23.7
Unreported	17.4	15.9	10.0	17.8	18.6
TOTAL	$180.0	$65.1	$104.0	$185.1	$192.7

TABLE 5-9

NET I/M REPAIR AND FUEL SAVINGS
(1979 $\$10^6$)

Income Group	Primary Case 7 ppm	 9 ppm	 12 ppm	9 ppm 2nd High Low Growth	9 ppm Daily Regional Growth
<$4800	$2.0	$1.7	$0.6	$1.8	$2.3
4800-6400	1.7	1.3	0.5	1.4	1.8
6400-8000	1.7	1.3	0.4	1.4	1.9
8000-9600	2.5	2.0	0.8	2.3	2.8
9600-12,100	4.2	3.5	1.3	3.7	4.9
12,100-16,000	7.2	5.0	1.9	5.4	6.8
16,000-24,100	8.3	6.8	2.5	7.3	9.5
>24,100	4.2	3.5	1.2	3.7	4.8
Unreported	3.2	1.8	0.8	3.0	3.7
TOTAL	$35.0	$26.9	$10.0	$30.0	$38.5

it impossible to guarantee that every car owner who requires repairs will receive a net savings. There is no assurance of interdependency within the magnitude of the repair costs and the fuel savings for each motorist. A motorist might be stuck with a repair bill and no fuel savings. However, in terms of the macroeconomic impact, the combined fuel savings and repair costs provide a greater savings in proportion to income for low income groups than for high income groups.

5.3.3 Transportation Control Measures

5.3.3.1 Gross Annual Cost

TCM's are necessary in a relatively few number of counties compared to I/M programs. The number of counties requiring this kind of control ranges from 27 under the 9 ppm daily regional growth scenario to 2 under the 12 ppm primary case.

TCM's are expensive to operate. The average gross annual cost per county ranges from $24.96 million for the 9 ppm primary case to $0.68 million under the 12 ppm primary case. The results for all five scenarios are presented in Table 5-10.

The gross costs are assumed to be paid by the local county governments. The average gross cost per county is calculated as a percentage of the total revenue for a range of county sizes. This provides an indication of the difficulty involved in paying the TCM cost. Table 5-10 displays these values. According to the Census of Governments (DOC, 1972), the range of county revenues in 1977 was from $109.4 million* for a county of 100,000 to 250,000 people to $9.29 million for a county of 10,000 to 25,000 people. The mean revenue for counties is $51.33 million.

Apparently, some counties could have considerable problems in paying for TCM without Federal assistance. If a small county with revenue on the

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* All of these revenues are in 1979 dollars.

TABLE 5-10

ANNUAL TCM GROSS COST
(1979 $\$10^6$)

	Primary Case			9 ppm 2nd High Low Growth	9 ppm Daily Regional Growth
	7 ppm	9 ppm	12 ppm		
Cost:					
Total	\$286.3	\$174.7	\$1.4	\$176.9	\$407.0
Average	25.9	13.6	0.7	17.7	15.1
Average percent of revenue by population:					
100,000-250,000	23.7%	12.4%	0.6%	16.2%	13.8%
10,000-25,000	278.8	146.4	7.5	190.5	162.5
Mean county revenue	\$50.5	\$26.5	\$1.3	\$34.5	\$29.4

low end of the range is forced to implement TCM, the cost could consume so much revenue that it would make continuation of county services practically impossible without additional revenue. A cost of $24.96 million corresponds to a tax increase of $383 per person using an average county population of 65,181 people (DOC, 1972). Examination of county populations indicates that none of the counties thought to need TCM have populations of less than 50,000. Therefore, while there is some potential for problems in affording TCM, it does not appear to be overly burdensome to any county.

5.3.3.2 TCM Fuel Savings

Fuel savings accrued under TCM cannot be used to offset the cost of control measures since no tax revenue can be gained. The savings are received directly by the motorist.

It is assumed that savings are proportional to VMT traveled. Table 5-11 indicates the percent of VMT traveled by income group. Also shown is the distribution of fuel savings by income.

Because of a lack of sufficient data points indicating the VMT per household by income class (only four points), it is impossible to make a meaningful estimate of the marginal increase in VMT by income. Without these data, the total effect of distribution of income as a result of TCM fuel savings cannot be estimated.

5.4 URBAN AND COMMUNITY IMPACT ANALYSIS

The purpose of this Urban and Community Impact Analysis (UCIA) is to examine the anticipated socioeconomic impacts of alternative NAAQS's for CO. To determine if revised air quality standards will adversely affect national urban policy, minority populations, and distressed communities, the following subsections evaluate the impacts of five alternative NAAQS's for CO on fiscal condition, income, and employment.

TABLE 5-11

DISTRIBUTION OF TCM FUEL SAVINGS
(1979 $$10^6$)

Income Category	Primary Case 7 ppm	Primary Case 9 ppm	Primary Case 12 ppm	9 ppm 2nd High Low Growth	9 ppm Daily Regional Growth
<$6400	$15.2	$9.5	$0.8	$10.0	$22.1
6400-8000	6.5	4.1	0.4	4.3	4.6
8000-16000	60.1	37.8	3.2	39.6	87.7
16000-24100	41.8	26.3	2.2	27.5	61.1
>24100	24.9	15.7	1.3	16.5	36.5
Unreported	14.7	9.2	0.8	9.7	21.5
TOTAL	$163.3	$102.6	$8.7	$107.6	$238.4

5.4.1 Fiscal Condition

One of the primary purposes of the UCIA is to identify those cities or types of cities likely to incur an additional economic burden due to the increased costs of a revised CO NAAQS. The following discussion details how revised CO standards might affect the fiscal condition of State and local governments, particularly those supporting larger urban areas.

There have been many studies identifying the most economically depressed cities in the United States. A recent study by the Urban Institute (1978) examined the country's 153 largest cities on the basis of three distress indicators:

- Population decline between 1970 and 1976 of 2 percent or more
- Per capita increases less than the all-city average in 1970
- Unemployment rates greater than the all-city average in 1976.

These cities were grouped into four categories, with category 0 comprising cities not exceeding any of the distress indicators and category 3 comprising cities exceeding all the distress indicators. Table 5-12 shows the number of urbanized areas requiring area source controls to meet five alternative CO standards and the number and percentage of these areas considered distressed, based on the above indicators. Table 5-13 shows the further disaggregation of these distressed urban areas by the four categories detailed in the Urban Institute study.

These tables indicate that a large number of the cities that would require CO source controls rank among the nation's most distressed cities. The percentage of cities requiring controls that are categorized as distressed range from 80 percent under the 9 ppm, second-high, low-growth scenario to 87.5 percent under the 12 ppm primary case scenario. These cities, largely older industrial centers in the northeast and midwest, will have to bear most of the costs imposed by a revised CO

Table 5-12

NUMBER OF DISTRESSED CITIES REQUIRING SOURCE CONTROLS

Standard (ppm)	Total # of Cities Requiring Source Controls	# of Distressed Cities Requiring Source Controls	% of Cities Requiring Source Controls that are Distressed
7 Primary Case	35	29	82.9%
9 Primary Case	31	25	80.6
12 Primary Case	16	14	87.5
9 2nd High, Low Growth	35	28	80.0
9 Daily, Regional Growth	39	33	84.6

TABLE 5-13

NUMBER OF DISTRESSED CITIES BY CATEGORY FOR FIVE ALTERNATIVE CO STANDARDS

	Category 3	Category 2			Category 1			Category 0
Standard (ppm)	All	Subset 1+3[a/]	Subset 1+2[a/]	Subset 2+3[a/]	Subset 1[b/]	Subset 2[c/]	Subset 3[d]	None
7 Primary Case	12	9	2	0	5	1	1	2
9 Primary Case	12	7	1	0	5	0	1	2
12 Primary Case	5	5	0	0	3	0	1	0
9 2nd High, Low Growth	12	9	2	0	5	0	1	2
9 Daily, Regional Growth	14	9	2	0	6	2	1	2

[a/] Subsets within categories can be summed to indicate total number of cities in each category.

[b/] Subset 1: Cities with population decline between 1970 and 1976 of 2% or more.

[c/] Subset 2: Cities with per capita incomes less than all-city average in 1970.

[d/] Subset 3: Cities with unemployment rates greater than all-city average in 1975.

SOURCE: The Urban Institute. 1978. "Distressed City Indicator." Cited in the President's National Urban Policy Report, 1978. Prepared by the Department of Housing and Urban Development.

standard. Tables 5-12 and 5-13 also illustrate that the actual number of distressed cities incurring costs due to required controls would be lowest under the 12 ppm primary case scenario and highest under the 9 ppm daily, regional growth alternative.*

5.4.2 Income

Another of the primary purposes of the UCIA is to examine the potential impacts of alternative CO NAAQS's on income levels. To project these impacts, this subsection discusses the costs and the fuel savings incurred by each income group and disaggregates these totals by race and by occupation.

Table 5-14 illustrates the distribution of people in each income category by racial group. Because these percentages reflect actual population numbers, the percentage of whites is greater than the percentage of non-whites in each category. The table, however, does reflect the fact that the ratio of non-whites to whites decreases as income levels increase.

Table 5-15 details the population distribution for each racial category among income groups. Both racial groups exhibit a substantial percentage concentration in the middle income categories. In the lowest two income categories, however, the percentage of non-whites is 37.8, almost twice the amount of whites in these income groups. Conversely, the percentage of whites in the highest two income groups is 45.5, nearly double the percentage of non-whites. Thus, despite the larger number of whites in each income category, non-whites comprise a disproportionate percentage of the lower income groups.

The distribution of FMVCP costs, inspection costs, I/M repair costs, I/M fuel savings, and TCM fuel savings is illustrated in Table 5-16 for each of the five alternative CO standards. It shows the total amount of

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*It is important to reemphasize that distressed cities are characterized by declining conditions. In this analysis, these cities are required to implement I/M and TCM programs in part due to a positive growth rate in emissions (1% per year). The positive growth rate may be inconsistent with other socio-economic characteristics in distressed areas, thus over-estimating the amount of control needed and cost burden imposed on area residents.

Table 5-14

PERCENTAGE DISTRIBUTION OF INCOME BY RACIAL GROUP

Income Category ($1979)	Percent White Population[a]	Percent Non-White Population
<$4800	79.1%	20.9%
4800-6400	83.2	16.8
6400-8000	85.6	14.4
8000-9600	86.7	13.3
9600-12,000	87.6	12.4
12,000-16,000	90.4	9.6
16,000-24,000	91.7	8.3
>24,000	93.9	6.19

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[a] Note that each income category sums to 100 percent.

SOURCE: U.S. Bureau of the Census. 1977. Current Population Reports. Series P-60, No. 105. Washington, D.C.: U.S. Government Printing Office.

Table 5-15

PERCENT DISTRIBUTION OF RACIAL GROUP BY INCOME CATEGORY

Income Category ($1979)	Percent White Population[a]	Percent Non-White Population
<$4800	13.6%	26.9%
4800-6400	7.3	10.9
6400-8000	6.2	7.5
8000-9600	5.9	6.7
9600-12000	8.5	9.0
12000-16000	13.0	12.4
16000-24000	19.4	13.2
>24000	26.1	13.4
TOTAL	100.0%	100.0%

a/ Note that each racial category sums to 100 percent.

SOURCE: Derived from data in the U.S. Bureau of Census, 1977. Current Population Reports. Series P-60, No. 105. Washington, D.C.: U.S. Government Printing Office.

TABLE 5-16

SUMMARY OF COSTS AND FUEL SAVINGS BY OCCUPATION

(1979 $\$10^6$)

Costs & Savings	Primary Case 7 ppm	Primary Case 9 ppm	Primary Case 12 ppm	9 ppm, 2nd High, Low Growth	9 ppm, Daily Regional Growth
FMVCP Costs[a/]					
White	$1804.00	$1804.00	$1804.00	$1804.00	$1804.00
Non-white	218.00	218.00	218.00	218.00	218.00
Inspection Fees					
White	189.00	175.80	92.60	197.50	200.70
Non-white	23.10	21.30	15.50	23.80	24.40
I/M Repair Costs					
White	172.2	155.40	75.60	173.40	186.20
Non-white	21.3	18.80	9.10	21.00	23.40
I/M Fuel Savings					
White	145.0	133.1	83.40	149.20	155.30
Non-white	17.6	16.0	10.00	18.10	18.80
TCM Fuel Savings					
White	132.15	83.04	7.03	87.18	193.24
Non-white	16.35	10.36	.87	10.72	23.76
Net Costs[b/]					
White	2050.53	2081.54	2044.25	2101.0	2004.84
Non-white	248.27	251.56	231.73	253.8	243.06

[a/] FMCVP Costs are assumed to be constant for all scenarios

[b/] Net costs equal total costs minus total savings costs and fuel savings resulting from each CO standard; it also disaggregates these absolute costs by racial group. The table, a best estimation of the costs and savings incurred by each racial group, is based on the assumption that the racial distribution of the population equals the racial distribution of car owners. It also is assumed that the costs for the FMVCP will be constant for all alternative standards.

The remainder of the costs and savings categories were calculated using the racial distributions shown in Table 5-14, thus indicating that whites will bear a larger share of the costs and savings than non-whites in each income group. As suggested by the relative impacts shown in Table 5-15, however, it appears that non-whites will bear a disproportionate share of the costs, particularly in the lower income areas.*

Note that the level of all costs and the distribution of these costs by racial group remain relatively constant for all scenarios but the 12 ppm primary case standard. The costs for this latter scenario are significantly lower than the costs imposed by the other alternative standards. Concurrently, however, the fuel and cost savings achieved by this standard are substantially lower than those achieved with other standards, thus mitigating the lower costs.

Table 5-17 shows the distribution of people in each income category by major occupational groups. Again, because these percentages are based on actual population figures, the percentage of white collar workers dominates every income category. As the income level increases, however, the percentage of white collar workers increases while the percentage of service and farm workers decreases.

Table 5-18 shows the population distribution of each occupational group among income categories. Rather than helping detail the actual costs incurred by each occupational group, this table can be used to determine the relative impacts felt by each occupational group. For example, only

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*However, by ignoring the distribution of control benefits, it may be misleading to say this share of costs is disproportionate.

TABLE 5-17

PERCENTAGE DISTRIBUTION OF INCOME BY OCCUPATIONAL GROUP
(Persons 14 Years and Older by Total Income, 1975)

Income Category[a/] ($1979)	White Collar	Blue Collar	Service Workers	Farm Workers
<$4,800	40.9%	23.9%	30.1%	5.1%
4,800-6,400	43.0	32.2	20.6	4.2
6,400-8,000	46.4	34.4	16.2	3.0
8,000-9,600	48.7	36.0	13.0	2.3
9,600-12,000	51.7	36.0	10.1	2.2
12,000-16,000	51.4	40.6	6.6	1.4
16,000-24,000	53.9	40.3	4.5	1.3
>24,000	74.9	20.0	2.8	2.3

[a/] Note that each income category sums to 100 percent.

SOURCE: Derived from data in U.S. Department of Commerce, Bureau of the Census. 1977. Current Population Reports. Series P-60, No. 105. Washington, D.C.: U.S. Government Printing Office.

TABLE 5-18

PERCENT DISTRIBUTION OF OCCUPATIONAL GROUP BY INCOME CATEGORY

(Persons 14 Years and Older by Total Income, 1975)

Income Category ($1979)	White Collar[a/]	Blue Collar	Service Workers	Farm Workers
<$4800	18.3%	16.6%	49.0%	40.8%
4800-6400	6.6	7.7	11.5	11.5
6400-8000	7.4	8.6	9.4	8.9
8000-9600	7.6	8.7	7.4	6.4
9600-12000	11.1	12.0	7.9	8.3
12000-16000	15.0	18.4	7.1	7.3
16000-24000	18.6	21.6	5.6	8.0
>24000	15.4	6.4	2.1	8.8
TOTAL	100.0%	100.0%	100.0%	100.0%

a/ Note that each occupational category sums to 100 percent.

SOURCE: Derived from data in the U.S. Bureau of the Census, 1977. Current Population Reports Series P-60, No. 105. Washington, D.C. U.S. Government Printing Office.

24.9 percent of all white collar workers are in the two lowest income ranges while 50.2 percent of all farm workers and 60.5 percent of all service workers fit into these lower income categories. Conversely 34 percent of all white collar workers are in the two highest income groups compared with 7.7 percent of all service workers and 16.8 percent of all farm workers. Clearly then service and farm workers comprise a disproportionate percentage of the lower income groups.

Table 5-19 illustrates the distribution of FMVCP costs, inspection costs, I/M repair costs, I/M fuel savings, and TCM fuel savings by occupation for each CO scenario. These tables disaggregate total costs and savings by white collar, blue collar, service worker, and farm worker categories. This table also is based on the assumption that the occupational distribution of car owners equals the occupational distribution of the population. It also is assumed that FMVCP costs will not vary with the stringency of alternative standards. Because this table was calculated using the percentages based on actual population, the actual costs incurred by white collar workers will be greater than those incurred by any other group. As indicated by the relative impacts shown in Table 5-18, however, service and farm workers will bear a disproportionate share of the costs, especially in the lower income groups.*

As illustrated in Table 5-15, the costs and the distribution of costs by occupational group remain relatively constant for all scenarios except the 12 ppm primary case. As before, the lower costs for this scenario are mitigated by lower savings, resulting in a similar relative economic impact of all scenarios, regardless of stringency.

5.4.3 Employment

The current level and/or distribution of employment is not expected to shift significantly as a result of revised CO standards. Employment levels will increase as jobs are generated by the greater number of I/M

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*However, the impact may be overstated since service and farm workers may not be located in urbanized areas having a CO problem and needing I/M and TCM programs. It may also be overstated because the distribution of control benefits is ignored.

TABLE 5-19

SUMMARY OF COSTS AND FUEL SAVINGS BY OCCUPATION
(1979 $\$10^6$)

	Primary Case			9 ppm 2nd High Low Growth	9 ppm Daily Regional Growth
	7 ppm	9 ppm	12 ppm		
FMVCP Costs[a/]					
White Collar	$1086.0	$1086.0	$1086.0	$1086.0	$1086.0
Blue Collar	425.0	425.0	425.0	425.0	425.0
Service Workers	188.0	188.0	188.0	188.0	188.0
Farm Workers	43.0	43.0	43.0	43.0	43.0
Inspection Fees					
White Collar	114.0	105.8	58.2	119.0	121.0
Blue Collar	73.9	68.6	37.7	77.1	78.2
Service Workers	19.7	18.4	9.9	20.5	21.0
Farm Workers	4.5	4.3	2.3	4.7	4.9
I/M Repair Costs					
White Collar	104.0	93.6	45.3	104.3	107.4
Blue Collar	67.3	60.7	29.6	67.8	71.6
Service Workers	18.0	16.2	8.0	18.2	19.2
Farm Workers	4.1	3.7	1.8	4.1	4.48
I/M Fuel Savings					
White Collar	87.2	79.9	50.2	89.8	93.6
Blue Collar	56.7	52.0	32.6	58.4	60.4
Service Workers	15.1	14.0	8.6	15.5	16.3
Farm Workers	3.6	3.2	2.0	3.6	3.8
TCM Fuel Savings					
White Collar	18.6	11.8	1.0	12.3	27.4
Blue Collar	5.0	3.1	0.3	3.3	7.3
Service Workers	0.7	0.4	0.0	0.5	1.0
Farm Workers	0.6	0.4	0.0	0.4	0.8
Net Costs[b/]					
White Collar	1296.4	1291.9	1236.5	1317.9	1377.9
Blue Collar	868.1	887.8	883.0	871.8	870.7
Service Workers	226.5	224.8	213.9	227.3	227.5
Farm Workers	51.3	51.3	48.9	51.6	51.6

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a/ FMVCP costs are assumed to be constant for all scenarios

b/ Net costs equal total costs minus total savings programs. Increased employment due to these programs, however, will not be extensive and must be attributed to all air quality standards requiring transportation compliance measures, thus making it difficult to discern that portion of increased employment resulting specifically from a revised CO standard.

Although the level of automotive repairs should increase due to implementation of an I/M program, this increase is not expected to significantly alter current employment levels in the automotive repair industry. Total national revenues from all automotive repairs, services, and garages equal $17 billion (1979 dollars) (DOC, 1977). The total revenues generated by repair costs under the 9 ppm primary case standard are $155.1 million or 0.9 percent of the total national revenues.

The greatest repair costs generated by an alternative standard equal $185.9 million under the 9 ppm daily regional growth standard and the least amount of repair costs equal $75.2 million under the 12 ppm, primary case standard. Because the repair costs for the five alternative standards examined comprise only 0.4 to 1.1 percent of total revenues in the automotive repair industry, it is not anticipated that the number of repairs required under alternative standards would significantly increase revenues or employment levels.

5.5 CONCLUSION

The results of the economic analysis and the UCIA indicate that no particular segment of the population is forced to pay a disproportionate amount of the total cost of mobile source control. Therefore, there are no significant adverse income distribution impacts.

The incremental nature of ownership of automobiles does indicate, however, that some individual households may face a disproportionate cost. This is due to the relatively small increase in numbers of automobiles owned by higher income households. (In other words, a constant portion of total income is not used to purchase more cars for all households.) As a result, a cost proportional to the number of cars may place additional burden on individual low income households.

REFERENCES FOR SECTION 5

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6. ECONOMIC IMPACT ON INDUSTRIAL POINT SOURCES

6.1 ECONOMIC ANALYSIS PROCEDURE

Section 4 presented data for both capital and annualized costs. In this section the data for both are presented in aggregate for each industry along with the number of plants controlled under each standard. The average cost per controlled plant to a company within the industry is estimated by dividing the total control cost by the number of plants controlling.

6.1.1 Data and Data Adjustments

6.1.1.1 Cost Data

The average annualized cost figures for plants requiring control must be altered to account properly for the effect of taxes. In their present form the figures represent the sum of operating costs, capital charges, and credits obtained from the use of CO as a fuel. Operating costs are the day-to-day expenditures required to operate the system. Capital charges are those items associated with owning the equipment including depreciation, property taxes, insurance, and interest on borrowed capital. A uniform capital recovery factor of 13.6 percent was chosen to estimate the effect of depreciation and interest (PEDCo, 1979). This portion of the capital charge is assumed to represent the only after-tax expense of owning the equipment. All other portions of the annualized cost represent before-tax expenses.* The cost of insurance, property taxes, and operating cost are deductible for tax purposes; thus, the magnitude of these costs is reduced by 48 percent, the corporate income tax rate.

Steam credits produced by heat recovery represent an income stream into the firm and are therefore taxable. This is true regardless of whether the steam is sold or used to reduce energy expenditures. The credits, therefore, also must be reduced by 48 percent. The tax-adjusted components of annualized cost, then, were added again to represent the average after-tax cost of regulation to firms within each industry.

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*Some financial analysts may disagree. For example, the uniform capital recovery factor could yield a stream of rental payments that is a before-tax expense item. Moreover, there is no room for investment tax credits and rapid write-off considerations using this approach.

6.1.1.2 Financial Data

In addition to the cost data, financial data collected to construct a profile of the industries were used to determine the impacts. The data form a set of "typical" firms in each industry.

Financial characteristics of firms in four major industries -- primary aluminum, carbon black, gray iron, and maleic anhydride -- were compiled in order to present a composite picture of the capital structure of each industry. The primary sources of this information were Moody's Industrial Reports (1979) and the Value Line Investments Survey (Bernhard, 1979), with background material on the industry provided by U.S. Department of Commerce, 1979 U.S. Industrial Outlook.

Production figures for the companies were used to determine typical size, while long-term debt, current liabilities, total stockholders' equity, and 1977 or 1978 capital investments were used to measure the financial strength of an average company in each industry. Also collected were debt/equity ratios and beta values; the latter is an estimator of risk as measured by the covariance between stock market activity and company stock prices. These figures are used by investors to determine whether or not an investment in a company is wise. As such, they serve to indicate whether it would be difficult to generate capital.

Where data were available for most of the firms within an industry, the mean of the values collected was used to represent a typical firm. In other instances, the data collected are used to establish a range within which a typical firm would fall. For example, the gray iron industry comprises 1300 separate companies, but data are available for only a few of each size; therefore, the range of data collected establishes a range within which any firm is likely to fall.

6.1.2 Capital Availability Analysis

The following steps were used to determine the ability of a firm to shoulder the burden of capital expenses incurred by pollution control requirements:

- Screen for industries significantly affected
- Compare capital required to historical capital expenditures of a typical company
- Compare capital cost to total long-term debt of a typical company
- Examine debt/equity ratios and beta values to determine the ability of a typical company to raise additional capital.

Screening consisted of examining the capital requirements for 1) the number of sources requiring control, and 2) the percentage of recent capital expenditure represented by controls under the most stringent standards. If the number of sources was limited (e.g., one plant) and capital costs were less than one percent of recent expenditures, the industry was removed from the study. (Fluctuations of one percent and less are assumed to be normal.) However, an industry comprised mostly of small firms is retained in the study since smaller changes in cost can affect small companies more significantly.*

The percentage of recent.capital expenditure represented by the control cost then was used to determine whether large amounts of additional capital need be raised or whether other investments would be delayed.

Capital costs also were compared to total long-term debt to indicate the ability of a company to absorb the expense. Small changes in debt will not affect the posture of a firm; large changes are examined for the effect on the debt/equity ratio. An increase in the debt/equity ratio or an already high ratio together with a high beta value is an indicator that raising capital may prove difficult.

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*They can affect large companies with a low profit margin.

6.1.3 Annualized Cost Impact Analysis

Figure 6-1 presents a diagram of the components of the annualized cost analysis. A screen for significant impact within the industries was used to eliminate industries whose price impact was less than 5 percent.*

The average cost impact was calculated by dividing the tax-adjusted aggregate annualized cost for each industry by the number of sources controlled under each standard. It is assumed that this cost is representative of the cost faced by a typical firm.

By further assuming full pass-through of cost, the increase in the average cost of production corresponds to the price increase, that is, increases in production cost would be offset by increases in price. Accounting for the effect of taxes (since 48 percent of the marginal revenue goes to corporate income tax), the price impact is approximately twice the increase in the average cost of production. The magnitude of the cost impact, viewed in terms of a percentage price increase, can be identified by comparing the price increase to a weighted average product price.

The price impact is examined to determine if there would be interference with the firm's competitive posture within its own industry. Foreign competition, transportation cost, and availability of sources of substitute products are considered within this effort.

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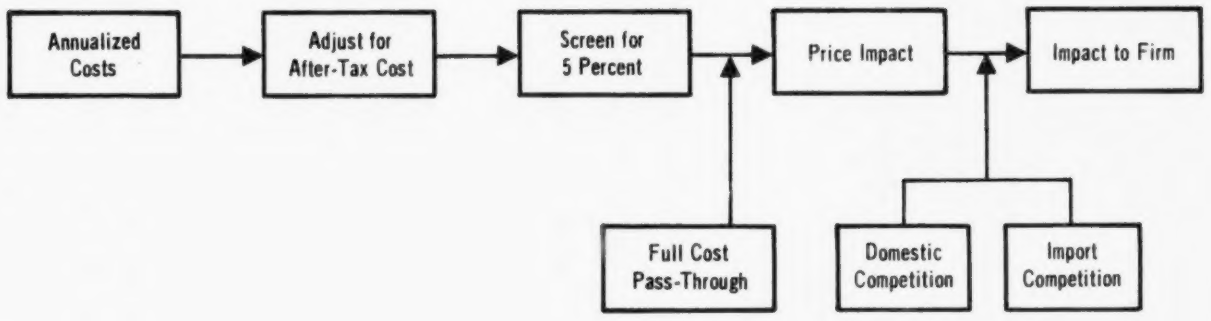
* Five percent was chosen for consistency with the EPA's "Criteria for Conducting Regulatory Analysis" (44 Federal Register 30988 (May 29, 1979)).

FIGURE 6–1
ANNUALIZED COST METHODOLOGY


Annualized Costs
Adjust for After-Tax Cost
Screen for 5 Percent
Price Impact
Impact to Firm
Full Cost Pass-Through
Domestic Competition
Import Competition

Because credits may be obtained by incineration and heat recovery, the annualized cost can be negative; that is, the value of the heat recovered (in steam) exceeds the annual cost of equipment operation. In these cases, the pollution control investment has been viewed as an exogenous investment; any benefits obtained are distributed to the shareholders and not reflected in a product price decrease. This conservative estimate is consistent with the economic theory that "the dollar price of goods and services resists being pushed down" (Solow, 1979). It is assumed, therefore, that corporations simply would not pass the cost savings on to the consumer.

6.2 ECONOMIC IMPACT TO INDUSTRY

6.2.1 Determination of Industries with Significant Impact

The regulatory impact analysis indicated that seven industries would require control under any alternative NAAQS investigated in this report; they are:

- Maleic anhydride
- Carbon black
- Steelmaking
- Gray iron
- Primary aluminum
- Automobile manufacturing
- Incineration.

The latter two industries, at maximum, show only one source controlling even under the most stringent standards.

The maximum capital expenditure incurred by the automobile manufacturing industry is $19,000 under any alternative. This amount is insignificant compared to investments made within the industry. General Motors, for example, invested $4.6 billion in 1978. Even for the much smaller American Motors Corporation, the $19,000 would represent less than 0.05 percent of the $41,233,000 invested in 1978.* The annualized cost of control to automobile manufacturing is $67,000. While the figures are not readily available, it seems safe to assume that the operating budget of a company is not less than its capital investments. Therefore, even for the small automotive corporation, the cost increase would be less than 0.02 percent.

The most stringent standard requires control of CO emissions from one municipal incinerator. Both the capital and the annualized cost of control are approximately $5000. Since the incinerator is operated by a State or local government, the increased expenditure would come from governmental revenues. The aggregate of local government revenues across the United States for 1977 was $105 billion. Wyoming, with $170 million, ranked last in revenues received. Individual counties had revenues ranging from $1.7 million to $29 million (EEA, 1979). A $5000 expense represents only 0.29 percent of the smallest county revenue. Therefore, because of control requirements, incineration is considered not to have a significant impact.

6.2.2 Profile of Industries Facing Regulatory Impacts

6.2.2.1 Maleic Anhydride

Seven companies produce 117 gigagrams (10^9 grams) of maleic anhydride annually at eight separate plants. The corporations have a mean debt/equity ratio of 31.9 percent and mean beta value of 0.96. The value indicates that the firms manufacturing maleic anhydride are of average risk from the investor's point of view.

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* Telephone interview with staff of Automotive Information Council.

For five of the companies, 1978 capital expenditures data were available. Three of the companies are large integrated corporations showing capital expenditures in excess of $500 million per company. Two smaller corporations' expenditures were investments for chemical production alone, not for the entire corporation, and these were around $33 million each.

6.2.2.2 Carbon Black

Carbon black, an organic compound often used as a reinforcing compound in rubber and plastic products, is produced by nine companies; financial data were available for six companies which produce approximately 4.3 billion pounds per year. The corporations producing carbon black have a mean debt/equity ratio of 30.5 percent and a mean beta value of 0.97. In 1977, four of these companies invested more than $1.7 billion in capital expenditures, an average of about $440 million each. The industry is associated with the petroleum refining industry by ownership and is concentrated in Louisiana, Texas, and Oklahoma.

6.2.2.3 Steel

The steelmaking industry was profiled using 10 of the largest firms in the industry, which account for almost all steel produced in the United States, or 97.1 million tons in 1978. The 10 companies have a mean debt/equity ratio of 31.9 percent, with the median at 34.5 percent.

The mean beta value for steel companies is 0.99, indicating that return on steel investments historically has been almost identical to that of the market as a whole. The 1977 capital expenditures of these companies ranged from a low of $30.2 million to a high of $865 million, with a mean of $236.5 million.

6.2.2.4 Gray Iron

It is difficult to describe a typical gray iron company because of the vast numbers and varieties of plants. Gray iron is produced at over 1300 foundries in the United States, ranging from giant casting foundries owned by auto manufacturers to small, family owned and operated foundries.

A representative cross section was drawn from the Iron Casting Society's Source Book. Data were collected for five companies ranging in size from 100 to 9000 tons per month; the results show wide variety. The debt/equity ratio ranged from 15 to 80 percent with no correlation to size; in fact, the two largest companies set the limits to the range.

Four of the companies were able to provide annualized cost data on pollution control presently installed to control other nonspecified pollutants. They ranged from $7500 to $800,000 per year with the larger values occurring in the larger firms. This range will be compared with required expenditure to indicate increased burden.

Total 1977 capital expenditures for all investments ranged from $60,000 to $24,000,000. The latter figure could be a one-year anomaly since it is far greater than any of the other firms; $300,000 is a more reasonable upper limit.

6.2.2.5 Aluminum--Primary Smelting

According to the Aluminum Association, primary aluminum is produced by 12 companies in 32 locations across the country. Approximately 5.19 million short tons of aluminum were produced in 1978. Financial information was available for 9 companies which account for 75 percent of the total or an average production rate of 432,783 tons per year per company.

The mean debt/equity ratio is 38 percent, with a range of 23.17 to 54.7 percent and a median of 36.1 percent. Capital expenditures (1977) could be found for only three companies with values ranging from $0.9 billion to $1.7 billion.

Complete presentation of financial and production data gathered for the industries discussed in Section 6.2.2 is shown in Tables 6-1 through 6-5. All of the ratios, percentages, and price impacts shown in later sections of this chapter are derived from the data presented in these tables.

6.2.3 Capital Cost Impacts

6.2.3.1 Maleic Anhydride

Two sources in the maleic anhydride industry require control to meet the current eight-hour standard (9 ppm). Compliance with the standard requires a capital expenditure of $1.14 million, an average of $570,000 for each plant. This represents less than 0.14 percent of the average 1977 capital investment for the companies. The cost represents only 1.7 percent of the smallest 1977 capital expenditure for any of the companies for which financial data were available.

The mean beta value for the firms producing maleic anhydride is 0.96, indicating both a slightly less-than-average risk associated with shareholders' investment and, combined with a debt/equity ratio of 31.9, a strong financial position. Even if the expenditures all were placed in long-term debt, (i.e., 100 percent debt financed), it would represent only a 0.04 percent increase in debt.

In addition to the current 9 ppm standard, three alternatives are being considered for the eight-hour standard. The most stringent option, 7 ppm, requires three plants to control for CO (compared to two plants under

TABLE 6-1

MALEIC ANHYDRIDE: FINANCIAL PROFILE

Company	Annual Production[a] (MG)	No. of Plants[a]	Long-Term Debt[b] ($\$10^3$)	Stockholders Equity[b] ($\$10^3$)	Debt/Equity Ratio[b] (%)	Total Capitalization[b] ($\$10^3$)	Beta Factor[c]
1	15	1	$2,007,379	$6,840,594	27.0%	$8,847,973	0.95
2	15	1	684,696	962,733	41.6	1,647,429	0.85
3	27	1	1,030,600	2,430,200	30.0	3,460,800	1.05
4	19	2	98,366	191,080	29.1	296,446	1.00
5	7	1	2,390,900	3,079,500	43.7	5,470,400	0.85
6	21	1	2,300,000	5,157,200	N/A	7,457,200	1.05
7	13	1	N/A	N/A	N/A	N/A	N/A

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[a] EEA, Inc. 1979. "Estimate of Control Costs and Simulation of Markets in Emission and Air Quality Offsets in Nonattainment Areas."

[b] Moody's Industrial Reports. 1979.

[c] Arnold Bernhard Co., Inc. June 1979. Value Line Investment Survey.

TABLE 6-2

CARBON BLACK: FINANCIAL PROFILE

Company	Plant Capacity (1977 10^6 lb)[b/]	No. of Plants[b/]	Long-Term Debt[c/] ($$10^3$)	Total Stockholders Equity[c/] ($$10^3$)	Debt/Equity Ratio[c/] (%)	Total Capitalization[c/] ($$10^3$)	Capital Investment ($$10^6$)	Beta Factor
1	670	5	$ 684,696	$ 962,733	41.6%	$1,647,429	$401.0	0.85
2	912	5	124,978	284,675	30.5	409,653	N/A	1.00
3	1031	8	785,552	1,937,558	26.2	2,723,110	501.0	0.85
4	472	3	766,658	3,087,117	19.9	4,309,174	N/A	1.10
5[a/]	427	4	1,066,074	2,880,397	27.2	3,946,471	584.4	1.10
6	130	1	387,000	651,400	37.3	1,038,400	174.8	0.90

[a/] Data given are for a parent corporation which owns more than 60 percent of the company.

[b/] EEA, Inc. 1979. "Estimate of Control Costs and Simulation of Markets in Emission and Air Quality Offsets in Nonattainment Areas."

[c/] Moody's Industrial Reports. 1979.

[d/] Arnold Bernhard Co., Inc. June 1979. Value Line Investment Survey.

TABLE 6-3

STEELMAKING: FINANCIAL PROFILE

Company	Total Capacity Annual Production[a] (1978 10^6 tons)	No. of Plants[b]	Long-Term Debt[b] ($\$10^3$)	Total Stockholders Equity[b] ($\$10^3$)	Debt/Equity Ratio[b,c] (%)	Total Capitalization ($\$10^3$)	Capital Investment (1977 $\$10^6$)	Beta Factor
1	8.5	8	$ 505,649	$1,451,514	25.72%	$1,957.163	$146.4	0.92
2	18.8	8	140,800	2,248,200	34.62	2,399,000	532.1	1.20
3	8.6	1	613,979	1,145,580	34.92	1,759,559	282.0	0.80
4	1.1	N/A	85,233	324,926	31.01	410,159	30.2	0.90
5	2.3	1	77,845	464,834	34.62	296.452	32.4	0.95
6	1.9	4	135,892	160,560	42.01	542,679	117.3	1.15
7	10.5	3	406,416	1,285,864	36.10	1,692,280	161.7	0.75
8	10.0	10	452,252	1,334,029	25.32	1,786,281	155.5	1.05
9	31.3	N/A	2,300,000	5,157,200	20.01	7,457,200	865.0	1.05
10	4.1	2	209,220	283,082	35.01	492,302	45.1	1.20

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[a] EEA, Inc. 1979. "Estimate of Control Costs and Simulation of Markets in Emission and Air Quality Offsets in Nonattainment Areas."

[b] Moody's Industrial Reports. 1979.

[c] Arnold Bernhard Co., Inc. June 1979. Value Line Investment Survey.

TABLE 6-4

GRAY IRON FOUNDRIES: FINANCIAL PROFILE

Company	Total 1978 Production[a/] (net tons/month)	No. of Plants/ Foundries[b/]	Long-Term Debt[b/] ($$10^3$)	Total Stockholders Equity[b/] ($$10^3$)	Debt/Equity Ratio[b/] (%)	Total Capitalization[b/] ($$10^3$)	Capital Expenditures ($$10^3$)	Beta Factor
1	100	1	$ 200.0	$1,000	80%	$1,200	$250	N/A
2	500	1	1,000.0	1,600	100	2,600	275	N/A
3	1,000	1	240.0	3,000	15	3,240	N/A	N/A
4	500	1	323.9	697	40	1,000	60	N/A
5	9,000	1	23,000.0	71,000	80	94,000	24,000	N/A

[a/] EEA, Inc. 1979. "Estimate of Control Costs and Simulation of Markets in Emission and Air Quality Offsets in Nonattainment Areas."

[b/] Moody's Industrial Reports. 1979.

[c/] Arnold Bernhard Co., Inc. June 1979. Value Line Investemnt Survey.

PRIMARY ALUMINUM: FINANCIAL PROFILE

Company	Primary Total Capacity (10^3 short tons)	No. of Plants (primary)	Long-term Debt[c/] ($\$10^3$)	Total Stockholders Equity[c/] ($\$10^3$)	Debt/Equity Ratio[c/] (%)	Total Capitalization[c/] ($\$10^3$)	Beta Factor[d/]
1	1,675.0	9	$1,166,000	$1,853,100	83.6%	$3,019,100	1.10
2	975.0	7	738,503	994,414	42.6	1,732,917	1.30
3	724.0	N/A	677,500	N/A	N/A	1,530,200	1.25
4	352.0	2	N/A	4,983,245	N/A	N/A	N/A
5[a/]	300.0	2	2,718,834	339,560	35.4	7,702,084	0.90
6	218.7	N/A	77,555	334,560	N/A	417,115	N/A
7	218.7	N/A	N/A	N/A	N/A	N/A	N/A
8	210.0	4	218,873	725,644	23.2	944,517	0.95
9	200.0	2	132,221	153,972	46.2	286,191	1.00
10	140.0	N/A	588,881	766,127	N/A	1,355,008	0.80
11	90.0	6	406,416	1,885,864	36.1	1,692,280	0.75
12	90.0	N/A	N/A	N/A	N/A	N/A	N/A

a/ Data given are for a parent corporation which owns more than 60 percent of the company.

b/ EEA, Inc. 1979. "Estimate of Control Costs and Simulation of Markets in Emissions and Air Quality Offsets in Nonattainment Areas".

c/ Moody's Industrial Reports. 1979

d/ Arnold Bernhard Co., Inc. June 1979. Value Line Investment Survey.

the current standard). The total capital cost is $1.9 million for the three plants, an average of $633,000 per plant. This is an 11 percent increase per plant over the current eight-hour standard requirements. The increase in capital required is approximately 0.1 percent of the capital invested in 1977. If the expenditure were 100 percent debt-financed, the incremental cost of the alternative over the current standard would increase long-term debt by 0.0044 percent.

The capital requirements for the maleic anhydride industry are shown in Table 6-6. The average capital cost imposed by the eight-hour alternative differs from the current standard by as much as 55 percent. The magnitude of the impacts relative to base investment reduces the significance of this increase. The impact against 1977 expenditures (i.e., less than one percent in all cases), indicates little real problem with capital availability; the difference between 0.14 and 0.2 percent should not hinder the formation of capital.

6.2.3.2 Steelmaking

To meet the proposed 9-ppm eight-hour standard, only one steelmaking plant must control CO emissions. The capital cost for the single plant is $4.4 million. The mean value of capital expenditures in 1977 for the steel industry was $236.5 million.

The control equipment capital cost, therefore, represents an average of 1.8 percent of the capital budget for typical corporations within the industry. 1977 capital investments ranged as low as $30.2 million for a single company; a $4.4 million cost would represent 14.6 percent of the capital expenditure for that firm.*

Despite problems with competition from foreign steel products, the industry maintains a mean beta value of 0.99 and a relatively low debt/equity ratio of 31.9. This indicates that while expansion of the industry may not occur, its financial structure is reasonably sound.

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*To look at capital requirements in isolation can give misleading results. Recall from Chapter 4 that on an annualized cost basis, CO control requirements result in a net cost savings, or credit.

Long-term debt for a typical steel producer is $494 million. Total debt financing of the capital investment would be only a 0.8 percent increase in debt. Complete debt financing would raise the debt/equity ratio to 32.2, an increase of 0.3 percent.

The 7 ppm eight-hour standard requires $21.4 million for the control of two plants or $10.7 million for each plant. A capital investment of this magnitude represents 4.4 percent of the average firm's capital investment in 1977. It should be noted, however, that since some firms invested in the range of $30 to $45 million in 1977, the pollution control requirements could use as much as one-third of the total capital spent in one year. This could cause a significant decrease in other investments. The magnitude of the expenditure is equivalent to 2.1 percent of the total long-term debt held by the average company. Such an increase, while not changing the debt/equity ratio significantly could cause a delay in some of the investment which would occur in the absence of control requirements.

The capital expenditure to meet the 12 ppm alternative is equal to $4.9 million to control one plant. This is an increase of $500,000 over the current standard. The more lenient standard allows the plant to choose the control strategy which produces the lowest annualized cost. It picks that option even though the capital costs are more. The expenditure represents 2 percent of the average capital investment for steel firms.

6.2.3.3 Gray Iron

The 9 ppm eight-hour standard requires 12 gray iron plants to control CO emissions at a capital cost of $120,000, averaging $14,167 per plant. This represents from 0.06 to 23.6 percent of the capital expenditures of foundries in 1977 (Company 2, Table 6-4). The expenditure represents 5.2 percent of the capital expentitures of our benchmark firm. The expenditure is 1.4 percent of the company's long-term debt.

TABLE 6-6

CAPITAL REQUIREMENTS FOR THE AVERAGE MALEIC ANHYDRIDE FIRM

8-Hour Standard	Capital Per Plant ($\$10^3$)	# of Plants Controlling	% of 1977 Capital Expenditure	% Increase in Long-Term Debt
9 ppm	$ 570	3	0.14%	0.040%
7 ppm	633	2	0.15	0.044
12 ppm	885	2	0.20	0.062

The 7 ppm eight-hour standard controls 18 plants at a capital cost of $281,000. This is an average of $15,611 per plant compared to the $14,167 under the current standard. The percentage of 1977 capital expenditures ranges from 0.06 to 26 percent and represents 5.6 percent of the benchmark firm. For a company whose capital investments are constrained, the change from current to a 7 ppm standard could reduce other capital investments by 3 percent.

The 12 ppm eight-hour standard shows that four foundries require control for attainment. The capital cost for the four plants is $54,000 or an average of $13,500 per plant. This represents the lowest average capital cost for gray iron control for any of the standards under consideration. This capital expenditure is within the 0.056 to 22.5 percent range compared to the 0.06 to 23.6 percent range. The capital expenditure thus falls by less than 1.1 percent vis-a-vis the current standard.

Table 6-7 presents the average capital cost for the gray iron industry. The percentage of 1977 capital expenditures is calculated from the expenditure of the benchmark firm.

In the case of the gray iron industry, the effect on the individual firm of changing the standard is not very significant. The maximum difference between the capital requirements under any of the standards is $2500. The primary effect of a change is to alter the number of sources subject to the control requirements. Even so, the maximum number of plants involved (12) is less than one percent of the foundries in the United States.

6.2.3.4 Primary Aluminum

To meet the 9 ppm eight-hour standard, a capital expenditure of $32 million is required for the control of two plants, an average cost of $16 million per plant. 1977 capital expenditure data were available for

TABLE 6-7

CAPITAL REQUIREMENTS FOR THE AVERAGE GRAY IRON FIRM

8-Hour Standard	Capital Per Plant ($\$10^3$)	# of Plants Controlling	% of 1977 Capital Expenditure	% Increase in Long-Term Debt
7 ppm	$15.61	18	5.7%	1.5%
9 ppm	14.17	12	5.2	1.4
12 ppm	13.50	4	4.9	1.3

only three companies which are of small size compared to the mean production of the industry. The figures for capital expenditure ranged from $90 million to $1.6 billion. This means that the capital required to meet the eight-hour standard should represent between 1.0 and 17.8 percent of the capital investment in any year for these aluminum-producing companies. The cost is 2.4 percent of the average capital expenditure.

The mean value for debt is $746.7 million; thus, the control expenditure would be 2.1 percent of the total debt for the company. This might delay some other non-mandatory investments by requiring generation of equity to cover the expenditure.*

Table 6-8 shows that the average capital requirements for firms controlling for CO vary only slightly between most of the standards. The difference between any of the possible eight-hour NAAQS's is limited, only 0.6 percent of the capital investment of the typical firm. Thus, the differential involved in changing the standards is small for the primary aluminum industry.

6.2.3.5 Carbon Black

Capital investments for the corporations producing carbon black totaled between $174.8 million and $584.4 million in 1977 with a mean of $440 million. The current eight-hour standard requires control of 11 sources, which make up almost 35.5 percent of all the sources (31) that produce carbon black. The total capital cost is $23.65 million or $2.15 million per plant. This is 0.5 percent of the mean expenditure or 1.3 percent of the smallest 1977 capital expenditure of companies within the industry. The industry should have little difficulty raising the capital for such investments, since 1) the debt/equity ratio of the firms is lower than for most industries (between 19.9 and 41.6), 2) the amount of credits obtained from investments is substantial, and 3) profits are up among most oil companies with which carbon black production is connected.

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*Remember, capital expenditures are being considered at this state of the analysis in isolation of cost pass-through possibilities. Both capital expenditures and cost pass-through, or price impacts, must be considered in evaluating net impact on the primary aluminum industry.

TABLE 6-8

CAPITAL COST TO THE AVERAGE ALUMINUM FIRM

8-Hour Standard	Capital Cost Per Firm ($\$10^3$)	# of Firms Controlling	% of 1978 Capital Investment	Percent of Long-Term Debt
7 ppm	$16,000	2	2.4%	2.1%
9 ppm	16,000	2	2.4	2.1
12 ppm	16,000	2	2.4	2.1

The most stringent option, the eight-hour 7 ppm standard, requires control by 12 sources -- 39 percent of all the plants in the United States -- at an average capital cost of $2.2 million per plant. The average cost increase per plant is $70,000 over the current standard, an increase in capital cost of only 3 percent for the project, representing less than 0.02 percent of the mean capital investment of the industry.

A change to the 12 ppm standard requires six sources to control. The average capital cost is $2.26 million, an increase of $110,000 over the current standard and an increase in the percentage of 1977 capital expenditure of only 0.06 percent.

Table 6-9 compares the average capital cost for firms needing control under each standard. The average capital cost does not differ by very much so that the difference in impact on the average firm is not significant. The primary effect would be a change in the number of sources subject to control requirements.

6.2.4 Annualized Cost Impacts

6.2.4.1 Industries with Positive Annualized Cost of Control

6.2.4.1.1 Primary Aluminum

Table 6-10 presents the after-tax annualized costs for the NAAQS options for the typical firm within the primary aluminum industry. A price increase of this magnitude may not have a significant effect on the industry for two reasons. First, transportation of aluminum costs approximately $0.014 per pound per ton-mile (EEA, 1979). Therefore, an increase in transportation distance of an alternative source of aluminum of 150 miles would completely offset the price increase. Second, the aluminum industry presently is experiencing increases in demand. Operating at 90 percent of full capacity (Bureau of Mines, 1978), sources within the

TABLE 6-9

CAPITAL COST TO THE AVERAGE CARBON BLACK FIRM

8-Hour Standard	Capital Cost Per Plant ($\$10^3$)	# of Plants Controlling	% of 1978 Capital Investment	% of Long-Term Debt
7 ppm	$2,220	12	0.50%	0.35%
9 ppm	2,150	11	0.48	0.34
12 ppm	2,260	11	0.51	0.36

TABLE 6-10

ANNUALIZED COST FOR AN AVERAGE ALUMINUM FIRM

8-Hour Standard	After-Tax Annualized Cost ($$10^3$)	# of Sources Controlling	% Increase in Price * (@ $0.62/lb)
7 ppm	$9,180	2	3.4%
9 ppm	9,180	2	3.4
12 ppm	9,180	2	3.4

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*Calculated by dividing before-tax annualized cost by annual revenue.

industry are in a strong position to pass through cost fully without causing a significant shift in intra-industry competitive posture.

6.2.4.1.2 Gray Iron

Table 6-11 compares the average after-tax annualized cost for gray iron foundries. As can be seen, none of the options under consideration cause an increase greater than one percent in product price for a foundry requiring control.

The after-tax annualized cost of the 9 ppm standard is $13,794 per plant, corresponding to an increase in the average cost of production of $0.001 to $0.006 per pound, depending on the size of the foundry. The increase in cost to our benchmark firm (Company 2, Table 6-4) would be $0.001,reflecting a 0.6 percent increase in price.

6.2.4.2 Industries with Negative Annualized Cost of Control

6.2.4.2.1 Maleic Anhydride

Two sources in the maleic anhydride industry must control CO to meet the current eight-hour NAAQS. The after-tax annualized cost is equal to -$17,500 per plant, which is assumed to be distributed among the stockholders. However, since the mean stockholders' equity for a company producing maleic anhydride is approximately $3.11 billion, this is only a $0.0005 per dollar return to the stockholders. The negative annualized cost does indicate that this is an investment which would not change the ability of a company requiring control to operate within the market.

All of the NAAQS options result in either no cost or negative annualized cost to the maleic anhydride industry. The magnitude of these after-tax costs are presented in Table 6-12.

TABLE 6-11

ANNUALIZED COST FOR AN AVERAGE GRAY IRON FIRM

8-Hour Standard	After-Tax Annualized Cost ($\$10^3$)	# of Sources Controlling	% Increase in Price* (@ $0.62/lb)
7 ppm	$12,921	18	0.57%
9 ppm	13,794	12	0.60
12 ppm	11,411	4	0.50

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*Calculated by dividing before-tax annualized cost by annual revenue.

TABLE 6-12

AVERAGE AFTER-TAX RETURN FROM CONTROL OF CO FOR AN AVERAGE MALEIC ANHYDRIDE FIRM

8-Hour Standard	Annualized Return ($10^3)	# of Sources Controlling	¢/$ Return on Stockholders' Equity
7 ppm	$28.9	3	$ 0.0009
9 ppm	17.5	2	0.0005
12 ppm	131.5	2	0.0042

The annualized cost associated with the investment for the 7 ppm standard is -$28,900 per firm, adjusted for taxes. This negative cost is an insignificant additional dividend to stockholders, approximately 0.0009 percent, but it is a savings to the average firm of $11,400 per year over the current standard.

6.2.4.2.2 Steelmaking

The current eight-hour standard requires controls for one steelmaking facility. The after-tax annualized cost was calculated to be -$40,000 per year per plant, representing a $0.003 payment for each dollar of stockholders' equity.

Table 6-13 compares the negative annualized costs incurred under the various alternatives. It should be noted that the steel industry has the largest fluctuation of average impact of any of the industries affected. The level of control required changes the profitability of the pollution control investment.

For the most stringent eight-hour standard, the after-tax annualized cost per plant is -$802,000. This is a 20-fold increase in the benefits above the current option and represents $0.06 per dollar in additional dividends over normal returns for companies using controls. Since no other standard has capital or annualized cost greater than that incurred under the 7 ppm eight-hour standard, it can be concluded that the steel industry does not experience a significant price impact due to alternative ambient CO standards.

6.2.4.2.3 Carbon Black

The after-tax annualized cost under the current eight-hour standard is -$478,000 per plant. The savings translates into a $0.028 return on each dollar of equity. Table 6-14 presents the annualized return for the current standards and the regulatory options under consideration.

TABLE 6-13

AVERAGE ANNUALIZED RETURN PER FIRM IN THE STEELMAKING INDUSTRY

8-Hour Standard	Annual Return per plant ($\$10^3$)	# of Sources Controlling	¢/$ Return on Stockholders' Equity
7 ppm	$ 40	1	$ 0.003
9 ppm	802	2	0.060
12 ppm	400	1	0.030

The after-tax annualized savings due to the most stringent standard (7 ppm eight-hour) is -$504,000 per plant. This is only $0.001 per dollar of equity increase over the current standard, while the 12 ppm standard yields an after-tax annualized cost for each plant of -$472,000 or a reduction in benefits of $6,000 per year. Again, this change does not affect any operations of these large corporations.

Since the impact on the operation of the firm is not affected by an increase in dividends of less than one percent, the differential impact of the regulatory options is not significant.

TABLE 6-14

AVERAGE ANNUALIZED RETURN PER FIRM IN THE CARBON BLACK INDUSTRY

8-Hour Standard	Annual Return per plant ($\$10^3$)	# of Sources Controlling	¢/$ Return on Stockholders' Equity
7 ppm	$504	11	$ 0.031
9 ppm	478	11	0.029
12 ppm	472	6	0.029

REFERENCES FOR SECTION 6

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APPENDIX A: FEDERAL MOTOR VEHICLE EMISSION CONTROL PROGRAM (FMVCP)

The costs of the FMVCP are estimated for the following vehicle categories:

- Light-duty vehicles
- Light-duty trucks
- Heavy-duty vehicles
- Motorcycles
- Aircraft.

The primary source of cost estimates for the vehicle emission standards was the regulatory analysis for ozone (EPA, 1979a). All costs are expressed in 1979 dollars.

The FMVCP controls gaseous emissions from combustion and evaporative emissions from fuel storage. Evaporative emissions consist of hydrocarbons only and, therefore, are not included in this discussion. FMVCP costs are presented by initial cost of emission controls, annualized capital charges, maintenance costs, changes in fuel economy, and costs for control at altitude.

A.1 LIGHT-DUTY VEHICLES

A.1.1 Initial Cost of Emission Control Systems

Effective standards of control for automobile carbon monoxide emissions began with the 1972 model year; the CO standard, effective through 1974, was 39.0 grams/mile. The standard was achieved using an air pump, which added an initial cost per vehicle of $30.00 (EPA, 1979a; Automotive News, 1979). The control system also reduced hydrocarbon emissions; the initial cost is apportioned equally between these pollutants, making the cost attributable to CO approximately $15.00 per vehicle.

In the 1975-79 model years, an oxidation catalyst (also called a dual catalyst) is used to achieve a standard of 15 grams/mile. The initial cost of the oxidation catalyst is $176 per vehicle (EPA, 1978a). Of this cost, approximately $12 is attributable to an exhaust gas recirculation (EGR) system used for NO_x reduction only. Therefore, $164 per vehicle was spent to reduce CO and hydrocarbons; again, the CO share is half, or $82 per vehicle.

The 1980 model year requires emissions of not more than 7.0 grams/mile; such a reduction is achieved using a three-way catalyst at an initial cost of $283 per vehicle (EPA, 1978a). Removing the EGR cost ($12) and allocating a share to hydrocarbons and NO_2, the CO portion is approximately $91.

The emission standard again is lowered, beginning with the 1981 model year, to 3.4 grams/mile. The three-way catalyst is augmented with an oxidation cleanup catalyst at an additional cost of $14 to $40 per vehicle The total control system cost to achieve a combined standard of 0.41/3.4/1.0 gram/mile for hydrocarbons, CO, and NO_x, respectively, ranges from $296 to $313 per vehicle (EPA, 1978a) (see Table A-1). Adjusting for the $12 EGR cost, the CO share is reduced to one-third or $100 per vehicle.*

The initial capital charges of FMVCP for CO in 1987 are estimated by multiplying the model year cost per vehicle by the projected or actual new car sales for any model year between 1972 and 1987. These products are summed to obtain the cumulative cost; Table A-2 presents these estimates.

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* EPA's Office of Mobile Source Pollution Control recommends equal apportioning.

TABLE A-1

COST OF COMPONENTS IN A THREE-WAY PLUS OXIDATION CATALYST SYSTEM

Component	Cost ($1979) Minimum	Cost ($1979) Maximum
Throttle position sensor	$ -	$ 2.2
PCV valve	1.1	1.1
HEI (less breaker point distributor)	7.7	7.7
TVS (spark)	-	2.2
Electric choke	1.1	1.1
EFE	4.4	4.4
EGR (backpressure)	7.7	7.7
TVS (EGR)	-	2.2
Stainless steel exhaust pipe (less steel pipe)	9.9	9.9
Air injection system	33.0	33.0
Air switching system	2.2	2.2
Feedback carburetor (less open loop carburetor)	8.8	8.8
Three-way plus oxidation catalyst	172.7	172.7
ECU	33.0	33.0
O_2 Sensor	3.3	3.3
H_2O temperature sensor	-	2.2
Inlet air temperature sensor	-	2.2
Engine speed sensor	-	2.2
Crank angle position sensor	-	2.2
EGR pintle position sensor	-	2.2
Evaporative system	11.0	11.0
TOTAL	$296.0	$313.0

SOURCE: Lingren, LeRoy H. (Rath and Strong, Inc.). March 1978. "Cost Estimation for Emission Control Related Components/Systems and Cost Methodology Description." EPA-460/3-78-002.

TABLE A-2

ANNUALIZED CAPITAL COST INCREASES FOR LDV'S DUE TO CO CONTROLS IN 1987

($1979)

Model Year	New Car Sales[a] 10^6	Initial Cost Increase Per Car ($)	Total Capital Cost ($$10^6$)	Scrappage Rate[a]	Annualized Cost[b] ($$10^6$)
1987	12.4	$ 100.0	$ 1240.0	1.00	$ 223.2
1986	12.3	100.0	1230.0	1.00	221.4
1985	12.3	100.0	1230.0	1.00	221.4
1984	12.0	100.0	1200.0	0.99	213.8
1983	11.5	100.0	1150.0	0.99	204.9
1982	11.0	100.0	1100.0	0.97	192.1
1981	11.1	100.0	1110.0	0.91	181.8
1980	11.5	91.0	1046.5	0.82	154.5
1979	10.9	82.0	893.8	0.71	114.2
1978	11.3	82.0	926.6	0.59	98.4
1977	11.2	82.0	918.4	0.47	77.8
1976	9.9	82.0	811.8	0.37	54.0
1975	8.2	82.0	672.4	0.27	32.6
1974	8.8	15.0	132.0	0.20	4.7
1973	11.5	15.0	172.5	0.16	4.9
1972	10.6	15.0	159.0	0.10	2.9
TOTAL	176.5		$13,993.0		$2,003.0

a/ McNutt, B., Dulla, R., and Lax, D. February/March 1979. "Factors Influencing Automotive Fuel Demand." SAE Paper 790226.

b/ Calculated assuming an 18 percent capital recovery factor (discount rate=12.5 %, average life=10 years).

A.1.1.1 Annualized Capital Charges

Table A-2 also presents the annualized capital costs of FMVCP in 1987. These costs were calculated by multiplying the total capital expenditure for each model year by a capital recovery factor of 18 percent (assuming the discount rate for households is 12.5 percent and that cars have an average life of 10 years) and a scrappage rate determined by vehicle age.

A.1.2 Maintenance Costs

The use of certain emission control systems leads to different costs and/or savings on typical maintenance relative to uncontrolled vehicles. Cars equipped with oxidation or three-way catalysts are assumed to realize a net annual \$5.50 savings (EPA, 1979a) (CO portion, see Table A-3). The items in Table A-3 indicate expected changes in the needed maintenance between uncontrolled vehicles and 1987 model year vehicles. The costs presented are considered to be a case of minimum savings since the prices assumed for sparkplug and point/condenser changes are probably low. The increase in oil change intervals, which at least in part is due to the use of unleaded fuel, is not considered. Also, O_2 sensor change intervals may be more than 30,000 miles by 1987, as that interval is being used or exceeded by some vehicles in production today. The \$55 miscellaneous cost for repair of emission control systems is in addition to an amount for any repairs attributable to inspection and maintenance programs.

No maintenance charges are experienced in pre-1975 vehicles. Table A-4 presents the estimated maintenance savings in 1987, calculated by multiplying the savings per vehicle by the 1987 population for each model year (i.e., new car sales for each model year times the scrappage rate).

TABLE A-3

MAINTENANCE CHANGES OVER 100,000 MILES

Maintenance	Total Cost of Maintenance	Cost Related to CO Control
Change O_2 sensor three times	3 x 16.5 = $49.5	1/3 x 49.5 = $16.5
Miscellaneous emissions system repairs	$55	1/3 x 55 = $18.3
Save five plug changes	5 x 11 = $(-)55	1/2 x (-55) = $-27.5
Save 10 point/condenser changes	10 x 11 = $(-)110	1/2 x (-110) = $-55
Save one muffler change	$(-)22	1/3 x (-22) = $-7.33
TOTAL	$(-)82.5 per 10 yrs	$ (-)55 per 10 yrs

SOURCE: Michael P. Walsh, Assistant Administrator, for Mobile Source Air Pollution Control. December 1, 1978. Memorandum to Walter C. Barber, Office of Air Quality Planning and Standards

TABLE A-4

ANNUAL OPERATING AND MAINTENANCE SAVINGS[a] FOR LDV'S DUE TO THE FMVCP IN 1987

($1979)

Model Year	Annual O&M Savings[b] ($)	Vehicle Population[c] (10^6)	Total Annual Savings ($\$10^6$)
1987	$ 5.5	12.4	$ 68.2
1986	5.5	12.3	67.7
1985	5.5	12.3	67.7
1984	5.5	11.9	65.5
1983	5.5	11.4	62.7
1982	5.5	10.7	58.9
1981	5.5	10.1	55.6
1980	5.5	9.4	51.7
1979	5.5	7.7	42.4
1978	5.5	6.7	36.9
1977	5.5	5.3	29.2
1976	5.5	3.7	20.4
1975	5.5	2.2	12.
1974	0.0	1.8	0.0
1973	0.0	1.8	0.0
1972	0.0	1.1	0.0
TOTAL		120.8	$639.0

a/ Assumes no change in savings between the dual catalyst and the three-way catalyst.

b/ Assumes 100,000 miles over a 10-year vehicle life.

c/ New car sales x scrappage rate.

A.1.3 Fuel Economy Credits

EPA's Emission Control Technology Division (Ann Arbor, Michigan) estimates the composite fuel economy of catalyst-equipped vehicles to be seven percent better than uncontrolled cars (EPA, 1979a; Murrell, 1979).

Data found in "Light Duty Automotive Fuel Economy Trends Through 1978" (Murrell, 1979) show the composite economy of 1978 California vehicles, which are controlled, to be about 7 or 8 percent better than uncontrolled vehicles at a constant weight mix (EPA, 1979a; Murrell, 1979). While it could be argued that fuel economy will continue to improve until 1987, a conservative representation of fuel economy benefits will use the 7 percent figure as a minimal fuel savings. No fuel economy is realized from air pump-equipped vehicles (1972-74 model years).

Table A-5 presents the savings due to FMVCP-related fuel economy. The average annual vehicle miles traveled (VMT) per car by vehicle age and the composite in use fuel economy for each model year are used to estimate the average gasoline consumption per vehicle by model year. Using a formula developed by the EPA Office of Mobile Source Pollution Control in Ann Arbor, Michigan, the EPA certified mileage data are converted to estimates of in-use road fuel economy. This number is generally lower than the certified mileage. Assuming a gasoline price of $1.00/gallon, the per vehicle cost of gasoline is obtained. Savings are calculated by multiplying per vehicle fuel costs by each model year's vehicle population (i.e., the new car sales times scrappage) and the fuel economy benefit. To obtain that portion due to CO, 1975-79 savings are divided by two, and 1980-87 savings are divided by three.* The total savings attributed to the CO standard is then approximately $1.8 billion.

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* Since catalysts are required by CO and HC only prior to 1981, the costs are shared equally by the two pollutants. After 1981, NO_x, CO, and HC equally share the savings.

TABLE A-5

ANNUAL FUEL ECONOMY SAVINGS FOR LDV'S DUE TO THE FMVCP IN 1987

Model Year	Annual VMT/Car[a]	Fuel Economy (mpg) EPA Certified[b] (mpg)	Fuel Economy (mpg) In-Use[c] (mpg)	Total Per Car Consumption (gallons)	Model Year Vehicle Population (10^6)	Fuel Economy Improvement	Savings: CO Share[d] (10^6 $)
1987	15,900	27.5	21.8	729	12.4	0.07	$ 210.9
1986	15,000	27.5	21.8	688	12.3	0.07	197.5
1975	14,000	27.5	21.8	642	12.3	0.07	184.3
1984	13,100	27.0	21.4	612	11.9	0.07	169.9
1983	12,200	27.0	21.4	570	11.4	0.07	151.6
1982	11,300	25.1	20.2	559	10.7	0.07	139.6
1981	10,300	23.5	19.1	539	10.1	0.07	127.0
1980	9,400	21.7	17.9	525	9.4	0.07	115.2
1979	8,500	20.1	16.9	503	7.7	0.07	135.6
1978	7,600	19.6	16.5	461	6.7	0.07	108.1
1977	6,700	18.3	15.7	427	5.3	0.07	79.2
1976	6,600	17.5	15.1	437	3.7	0.07	56.6
1975	6,200	15.8	14.0	443	2.2	0.07	34.1
1974	5,900	14.2	12.9	457	1.8	-	-
1973	5,500	14.2	12.9	426	1.8	-	-
1972	5,100	14.5	13.1	389	1.1	-	-
TOTAL					120.8		$1709.6

Footnotes on following page.

TABLE A-5

ANNUAL FUEL ECONOMY SAVINGS DUE LDV'S DUE TO THE FMVCP IN 1987

(continued)

a/ EEA. August 1979. "Alternative Short-Term NO_2 Standards: Second Round Analyses." Prepared for U.S. EPA. Table 4-10.

b/ McNutt, B.; Dulla, R.; and Lax, D. February/March 1979. "Factors Influencing Automotive Fuel Demand." SAE Paper 790226; Murrell J.D., March 2, 1979. "Light Duty Automobile Fuel Economy Trends Through 1978. SAE Paper 780036.

c/ Based on Ann Arbor analysis of in-use to certified mileage relationship.

d/ Switches from 1/2 to 1/3 after 1979; assumes $1.00/gallon.

A.1.4 Use of Unleaded Fuel

Catalyst control systems require the use of unleaded fuel. Presently, unleaded gasoline is $0.04 to $0.05/gallon more expensive than regular gasoline, with some fluctuation. This trend is due in part to a slightly higher refining cost of unleaded fuel and in part to pricing strategies of gasoline retailers. Some experts predict that as unleaded fuel becomes the "high volume" fuel towards 1987, the price differential will be reduced. In any case, with the DOE proposed "tilt" rule as published in the April 11, 1979, Federal Register, the price differential will not be greater than $0.04/gallon. The rule provides maximum allowable price differentials between leaded and unleaded gasoline.*

Table A-6 shows that a $2.0 billion cost is incurred by the use of unleaded instead of leaded fuel in 1987. Again, this cost is incurred due to the entire FMVCP. To determine the CO portion, 1975-79 costs are divided by two, while 1980-87 costs are divided by three, yielding a total CO cost due to unleaded fuel of approximately $733 million.

A.1.5 Emission Control at Altitude

Emission control at altitude is not required for model years 1979-80 as a result of the 1977 Clean Air Act Amendments (EPA, 1979a, Appendix D), although altitude regulations may be in force again by the 1981 model year. The final form of these regulations was presented for the 1981 and subsequent model years in Federal Register Vol. 45, No. 17 on January 24, 1980, at a cost of $10.3 million or 5.1 for CO. In addition, the Clean Air Act requires stringent altitude controls beginning with the 1984 model year. Thus, the program cost can be estimated only within a fairly wide range, from $55 million to $1,039 million (EPA, 1978b,c). To consider only CO control, the dollar amounts are divided in half, yielding $27.5 million to $519.5 million. The mid-point of the

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* Consistent with the direction of EPA's Office of Mobile Source Air Pollution Control, Ann Arbor, Michigan, a value of $0.03 per gallon is assumed.

TABLE A-6

COSTS TO LDV'S OF USING UNLEADED FUEL DUE TO FMVCP IN 1987
($1979)

Model Year	Fuel Consumed Annually Per Car[a/] (gallons)	Vehicle Population (10^6)	Unleaded Price Differential ($/gallon)	CO Portion[b/] ($\$10^6$)
1987	729	12.4	$ 0.03	$ 90
1986	688	12.3	0.03	85
1985	642	12.3	0.03	79
1984	612	11.9	0.03	73
1983	570	11.4	0.03	65
1982	559	10.7	0.03	60
1981	539	10.1	0.03	54
1980	525	9.4	0.03	49
1979	503	7.7	0.03	58
1978	461	6.7	0.03	46
1977	427	5.3	0.03	34
1976	437	3.7	0.03	24
1975	443	2.2	0.03	15
TOTAL				733

[a/] Calculated from VMT per year per car (USEPA, OQWM, Mobile Source Emission Factors, EPA-400/9-78-005, March 1978) divided by typical model year miles per gallon. (B. McNutt, R. Dulla, and D. Lax. February/March 1979. "Factors Influencing Automotive Fuel Demand". SAE Paper 790226).

[b/] Switches from 1/2 to 1/3 after 1979.

range will be used or $273. Adding the cost for previous years, a cost of $275 million is estimated.

A.1.6 Tailpipe Standard Waivers

The nation's automobile manufacturers have been petitioning the EPA for a waiver from meeting the 1981 3.4 grams/mile emission standard. EPA has granted two-year waivers to five companies: Chrysler Corporation (one-half of projected production), American Motors' (four-fifths of production), British Leyland (one-fifth of production) (Federal Register, Vol. 49;223, 1979), Toyota (small fraction of production), and General Motors (a one-year waiver for a small portion of its production).

In total, approximately 20 percent of 1981-1982 model year vehicles (about 4.4 million cars) will continue to meet a 7.0 grams/mile versus a 3.4 grams/mile standard at a per vehicle saving of $9.00 (see Table A-1). The impact on estimated cost is approximately $39.8 million in initial capital cost savings and annualized cost savings of almost $6.8 million. These savings account for 0.2 percent of the cumulative capital cost without any waivers and0.3 percent of the total annualized cost.

In addition, new requests for waivers were made by Toyota, Lotus, Chrysler, AMC, and GM (Federal Register Vol. 1397, No. 7, draft). Preliminary indications are the waivers will be granted for a portion of the engine families for Lotus, General Motors, and American Motors Corporation. The engines will be subject to an interior standard of 7.0 gpm for the 1981 model year. These additional waivers involve an additional 10 percent of the 1981-1982 model years at a savings of $9.00 per vehicle for an additional capital savings of $19.9 million or annualized savings of $3.4 million.

A.2 LIGHT-DUTY TRUCKS

A.2.1 Initial Cost of Emission Control Systems

The initial costs of emission control systems for light-duty trucks (LDT) were assumed to be the same as for automobiles from 1972 to 1982. The standard schedule is slightly different from that for LDV's in the 1979-82 period, however, since the most stringent standards are implemented in 1983 instead of 1981 and the interim standard applies for four years while it is only one year for LDV's. The estimate of cost for emission control for model years 1983 to 1987 was taken from the regulatory analysis for LDT's (EPA, 1979b). The cost represents only that portion attributed to the CO standard.

The calculation of 1987 cumulative capital costs is shown in Table A-7.

A.2.2 Annual Costs of LDT Emission Control

Table A-8 presents the annualization of these capital charges. To be conservative, no maintenance savings or fuel economy savings are credited to LDT. The annual costs, therefore, represent the annualized capital charges and the added costs of unleaded gasoline. Table A-9 presents the calculation procedure for estimates of the latter.

A.2.3 Emission Control at Altitude

The method for determining the cost of LDT emission control at altitude is taken directly from the ozone analysis (i.e., the ratio of LDT to LDV multiplied by the cost of LDV). The cost is thus 36 percent of the LDV altitude cost or $100 million.*

A.3 HEAVY-DUTY VEHICLES

A.3.1 Initial Cost of Emission Control Systems

Heavy-duty vehicle (HDV) control equipment costs for model years 1983-1987 were obtained from the regulatory analysis of heavy-duty vehicles (EPA, 1978d). Since control costs for HDV's for model years prior to 1983 are not available, an estimation technique recommended by EPA's Office of

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* Assuming 120.8 million LDV's and 43.31 million LDT's (see Tables A-3 and A-8).

TABLE A-7

CAPITAL COST OF LDT CONTROL DUE TO FMVCP IN 1987
($1979)

Model Year	New LDT Sales[a/] (10^6 vehicles)	Initial Cost Increase Per Vehicle ($)	Total Capital Cost ($\$10^6$)
1987	4.61	$ 105.72	$ 487.4
1986	4.54	105.72	480.0
1985	4.50	105.72	475.8
1984	4.31	105.72	455.7
1983	4.03	105.72	426.1
1982	3.75	82	307.5
1981	3.83	82	314.1
1980	3.88	82	318.2
1979	3.53	82	289.5
1978	3.78	82	310.0
1977	3.50	82	287.0
1976	2.90	82	237.8
1975	2.09	82	171.4
1974	2.25	15	33.8
1973	2.56	15	38.4
1972	2.00	15	30.0
TOTAL			$4662.7

a/ McNutt, B.; Dulla, R.; and Lax, D. February/March 1979. "Factors Influencing Automotive Fuel Demand." SAE Paper 790226.

TABLE A-8

ANNUALIZED COST OF FMVCP FOR LDT'S DUE TO CO CONTROL IN 1987 ($1979)

Model Year	Capital Cost ($$10^6$)	Scrappage Rate[a]	Annualized Capital Charge[b] ($$10^6$)
1987	$ 487.4	1.00	$ 87.7
1986	480.0	1.00	86.4
1985	475.8	0.99	84.8
1984	455.7	0.97	79.6
1983	426.1	0.95	72.9
1982	307.5	0.93	51.5
1981	314.1	0.90	50.9
1980	318.2	0.86	49.3
1979	289.5	0.83	43.3
1978	310.0	0.77	43.0
1977	287.0	0.71	36.7
1976	237.8	0.65	27.8
1975	171.4	0.57	17.6
1974	33.8	0.50	3.0
1973	38.4	0.44	3.0
1972	30.0	0.38	2.1
TOTAL			$739.6

a/ McNutt, B.; Dulla, R.; and Lax, D. February/March 1979. "Factors Influencing Automotive Fuel Demand." SAE Paper 790226.

b/ Based on 100,000 miles per vehicle over a 10-year life; assumes a 12.5 percent discount rate.

TABLE A-9

INCREASE IN ANNUAL FUEL COST FOR LDT'S DUE TO USE OF UNLEADED GASOLINE

Model Year	VMT Per Car Per Year[a]	Fuel Economy Certified[a] (mpg)	Fuel Economy In-Use (mpg)	Annual Fuel Use Per Vehicle (gallons)	Vehicle Population (10^6)	CO Share (1979 $\$10^6$)
1987	15,900	22.8	18.6	855	4.61	$39
1986	15,000	22.8	18.6	806	4.54	37
1985	14,000	22.1	18.2	769	4.46	34
1984	13,100	22.2	18.2	720	4.18	30
1983	12,200	21.6	17.8	685	3.83	26
1982	11,300	20.0	16.8	673	3.49	35
1981	10,300	18.7	15.8	652	3.45	34
1980	9,400	17.5	15.1	623	3.34	31
1979	8,500	17.3	15.0	567	2.93	25
1978	7,600	17.0	14.8	514	2.91	23
1977	6,700	16.5	14.4	465	2.49	17
1976	6,600	15.5	13.8	478	1.89	14
1975	5,900	12.9	12.1	488	1.19	9
TOTAL					43.31	$354

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[a] EEA. August 1979. "Alternative Short-Term NO_2 Standards: Second Round Analyses." Prepared for U.S. EPA.

[b] Assumes $1.00/gallon.

Mobile Source Air Pollution Control was used.* It is assumed that emission control costs for pre-1983 model years are roughly equal to the incremental cost of model years 1983 to 1987. Since these costs are divided between two pollutants (hydrocarbons and carbon monoxide), the cost for CO may be estimated by the incremental cost of the later model years. These hardware costs are approximately $185 per diesel vehicle and $204 per gasoline vehicle. The total capital cost is presented in Table A-10.

A.3.2 Annualized Cost of HDV Emission Control

Table A-11 presents the annual capital cost of emission control systems. Since no maintenance or fuel economy savings have been substantiated, none are credited to HDV. There is, however, the additional cost of unleaded fuel for gasoline-powered HDV's. Using projections of gasoline HDV mileage and population in 1987 (Argonne, 1979), and assuming a $.03 per gallon premium for unleaded fuel, the annual cost of unleaded fuel attributed to CO is approximately $305 million.

The total annualized cost is the sum of capital charges and unleaded fuel costs, or $431 million.

A.4 MOTORCYCLES

The cost to the consumer of the 1978 and 1980 motorcycle emission standards will be approximately $138.8 million over the 1978-82 time frame (EPA, 1976). This figure includes costs due to fuel consumption. The share attributable to carbon monoxide is 50 percent, yielding $69.4 million. Dividing by five to obtain a simple annual cost (i.e., total cost divided by five years of implementation) yields $13.5 million.

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* Michael P. Walsh, Assistant Administrator for Mobile Source Air Pollution Control. December 1, 1978. Memorandum to Walter C. Barber, Office of Air Quality Planning and Standards.

TABLE A-10

CAPITAL COSTS FOR HDV'S
($1979)

Model Year	New Gasoline HDV Sales (10^3)	New Diesel HDV Sales (10^3)	Gasoline Capital Cost (\$$10^6$)	Diesel Capital Cost (\$$10^6$)	Total Capital Cost (\$$10^6$)
1987	505	251	$103.0	$46.4	$149.4
1986	492	239	100.4	44.2	144.6
1985	480	227	98.0	42.0	140.0
1984	468	216	95.5	40.0	135.4
1983	456	206	93.0	38.1	131.1
TOTAL					$700.5

TABLE A-11

ANNUALIZED COST OF FMVCP FOR HDV CONTROLS IN 1987
($1979)

Model Year	Capital Cost ($$10^6$)	Annualized Capital Charge ($$10^6$)
1987	$149.4	$26.9
1986	144.6	26.0
1985	140.0	25.2
1984	135.4	24.4
1983	131.1	23.6
TOTAL		$126.1

Motorcycle emission standards for the 1983-84 model years and for the 1985 and subsequent model years have not yet been proposed. The cost of these regulations was estimated to be $100 per motorcycle relative to uncontrolled vehicles (EPA, 1976). This represents a $150/motorcycle initial cost and a $50/motorcycle fuel savings. Assuming one million motorcycles are sold annually, the cost of this program in any year is approximately $100 million. The CO share of this estimate is one-third or $33 million; HC and CO are reduced by 90 percent and NO_x could be reduced by 75 percent. The total annual cost of the motorcycle program for CO control, therefore, is $46.5 million.

A.5 AIRCRAFT

Using an estimated cost of $1.5 billion over 18 years,* an annualized cost of $41.7 million dollars is calculated to estimate the portion of aircraft FMVCP attributable to CO. This estimate is a preliminary estimate and is subject to change in the future.

A.6 SUMMARY

Table A-12 presents a summary of the FMVCP cost attributable to CO in 1987.

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* Provided by EPA's Office of Mobile Source Air Pollution Control.

TABLE A-12

TOTAL ANNUAL COST OF THE FMVCP IN 1987

	Annual Cost of CO Control ($1979 \$10^6$)
Passenger Cars (LDV)	
Hardware	$2003.0
Fuel economy	(1709.6)[a]
Unleaded gasoline cost	733.0
Operating and maintenance	(639.0)[a]
Altitude controls	278.0
	665.4
Light-Duty Trucks (LDT)	
Hardware	739.6
Fuel economy	0.0
Unleaded gasoline cost	354.0
Operating and maintenance	0.0
Altitude controls	100.0
	1193.6
Heavy-Duty Vehicles (HDV)	
Hardware	126.1
Unleaded gasoline cost	305.0
	431.0
Motorcycles	
All costs	46.5
Aircraft	
All costs	41.6
TOTAL	$2378.1

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[a] Indicates negative costs

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APPENDIX B

STATIONARY SOURCES: METHODOLOGY AND ASSUMPTIONS

B.1 INDUSTRY COVERAGE

B.1.1 Selection Criteria

The industries included for evaluation were selected from a preliminary list of potentially significant CO sources (PEDCo, 1979b). Average process and stack parameters were gathered from recent EPA regulatory and engineering studies for approximately 25 industrial processes. Table B-1 lists those source categories identified. The resulting data (PEDCo, 1979b) indicated, for each process, two production sizes typical of the range of operation and the uncontrolled emission rate, stack height and exhaust gas velocity, temperature, and volume appropriate to each size. Probable control equipment and efficiencies also were identified.

In order to focus the derivation of process-specific control costs on those processes likely to experience some need for emission reduction under any of the alternative standards, it was decided to screen the source list by evaluating the air quality impact of each "model" source.

B.1.2 Air Quality Modeling of "Model Sources"

A single source dispersion model, PTMAX, was used to calculate a predicted maximum concentration for each source (and size of source). PTMAX is an interactive program which calculates the maximum short-term (one-hour) ambient concentration from any point as a function of exhaust and stack characteristics, wind speed, and stability. The program is part of the User's Network for Applied Modeling of Air Pollution (UNAMAP) maintained

TABLE B-1

POTENTIALLY SIGNIFICANT PROCESS SOURCES OF CO

- Petroleum refineries
- Carbon black
    - furnace/oil
    - furnace/gas
- Kraft pulp and paper
- Iron foundries
- Steelmaking
    - sintering
    - basic oxygen furnace (BOF)
- Primary aluminum
- Gas pipelines
- Electric utilities
- Acrylonitrile
- Maleic anhydride
- Industrial combustion
- Charcoal
- Formaldehyde
- Dimethylterephthalate
- Phthalic anhydride
- Coke production
- Cyclohexanol
- Gas-fired process heaters
- Ethylene dichloride
- Reciprocating internal combustion engines

by the Division of Meteorology, EPA. To determine their maximum impact, sources were modeled using their uncontrolled emission rate; no background level was assumed.

PTMAX predicts one-hour levels only. Because the ambient standards consider both one- and eight-hour averaging periods, a method for converting the predicted one-hour into expected eight-hour concentrations was necessary. Persistence factors of 0.5 and 0.7, which represent ratios of eight-hour to one-hour concentrations exhibited by monitored data, were used (Schewe, 1979). The 0.7 factor represents a ratio of maxima and, therefore, produces a worst case estimate. The results of the PTMAX air quality modeling are presented in Table B-2.

Eight of the model processes experienced potentially significant air quality impacts. For the screen, "significant" was defined as 50 percent or more of the most stringent ambient standard to be considered. These processes were:

- Basic oxygen furnace
- Aluminum anode prebake
- Aluminum prebake cells
- Maleic anhydride
- Cyclohexanol
- Formaldehyde
- Ethylene dichloride
- Coke oven charging.

B.1.3 NEDS Screen

The PTMAX modeling indicated potential impacts for source categories with a specific set of process and stack characteristics. The probability that actual sources may deviate from those "model" parameter sets created the need to screen further process categories which might cause ambient violations.

TABLE B-2

PTMAX MODELING RESULTS

			8-hour Bounds		
Industry	Process Source	Size	Lower (ppm)	Upper (ppm)	Distance (km)
Petroleum refining	Catalytic cracking	25,000 BPD	1.49	2.09	0.80
		90,000 BPD	1.58	2.21	1.56
Carbon black	Furnace process	176,000 TPY	1.77	2.48	17.50
		44,000 TPY	2.54	3.55	0.62
Kraft pulp	Recovery boiler	1,500 TPD	0.003	0.004	2.07
		1,000 TPD	0.002	0.003	1.82
Kraft pulp	Kiln	1,500 TPD	0.19	0.26	0.51
		1,000 TPD	0.17	0.23	0.40
Gray iron	Cupola	25 TPH	1.71	2.40	0.37
		1 TPH	0.79	1.09	0.21
Iron and steel	Sinter plant	3.65 MTPY	1.00	1.40	1.13
		1.19 MTPY	0.91	1.27	0.58
Steelmaking	Electric arc	0.10 MTPY	0.02	0.03	0.63
		1.13 MTPY	0.03	0.04	1.58
Steelmaking	BOF	1.61 MTPY	29.92	41.89	0.62
		3.78 MTPY	62.20	87.02	0.60
Primary aluminum	Prebake cells	225,000 TPY	0.87	1.21	1.01
		140,000 TPY	1.12	1.56	0.36
Primary aluminum	Anode prebake	225,000 TPY	7.32	10.24	0.36
		140,000 TPY	6.64	9.30	0.38
Primary aluminum	HSS cell	225,000 TPY	0.45	0.63	1.44
		140,000 TPY	0.55	0.77	0.99
Gas pipeline	Engine exhaust	1,500 HP	0.004	0.005	0.22
Electric utility*	Coal	1,000 MWe	0.001	0.001	2.50
		100 MWe	0.000	0.001	1.15
Electric utility*	Residual oil	1,000 MWe	0.001	0.001	2.24
		100 Mwe	0.000	0.001	1.15
Electric utility*	Gas	1,000 MWe	0.001	0.001	2.29
		100 MWe	0.000	0.000	41.93

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* 75 m. stack height.

B.1.4 Source Category Control Cost Development

For the 14 potentially significant processes screened in the preceding two steps, capital and annualized costs were obtained for two typical operating rates within each process category.* The technology selection was based on currently demonstrated control equipment; no experimental technology was considered (PEDCo, 1979a).

As indicated, costs (capital and annualized) were developed for two process sizes which are deemed reflective of the range of typical operation. The two cost estimates were used to construct an exponential equation for each process category which, upon inputting a source's specific annual capacity or production level, would produce the costs of a unit of appropriate size. The log-log curve represented by the equation is used to capture economies or diseconomies of scale inherent in the two size-specific point estimates.

In three cases, a single process size was indicated, hence the control costs for that size were assumed to be linear per unit of production (a uniform $/ton of product). For one process, the conical wood incinerator, the costs of control do not vary by size; therefore, the capital and annualized costs are level.

B.2 TOTAL COST METHODOLOGY

B.2.1 Evaluation of Ambient Impact

In order to determine the costs incurred by each alternative standard, the evaluation of the extent to which existing sources violate mandated concentration levels constitutes the first step. PTMAX was applied to the 700 point sources in the NEDS subfile. For the purposes of costing,

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* There are several exceptions where only one size was costed. See PEDCo, 1979b.

TABLE B-2 (cont'd)

PTMAX MODELING RESULTS

Industry	Process Source	Size	8-hour Bounds Lower (ppm)	8-hour Bounds Upper (ppm)	8-hour Bounds Distance (km)
Acrylonitrile	Absorber vent	0.154 MTPY	0.60	0.83	0.61
		0.121 MTPY	0.57	0.80	0.61
Maleic anhydride	Condenser	0.027 MTPY	5.65	7.90	0.31
		0.006 MTPY	4.33	6.06	0.29
Industrial boilers	Coal	50 10^6 Btuh	0.001	0.002	0.41
		250 10^6 Btuh	0.001	0.002	0.58
Industrial boilers	Distillate	1 10^6 Btuh	0.000	0.000	0.21
		10 10^6 Btuh	0.001	0.002	0.25
Industrial boilers	Gas	1 10^6 Btuh	0.000	0.000	0.21
		10 10^6 Btuh	0.001	0.001	0.25
Charcoal	Kiln	215 Lbh	0.10	0.15	0.17
Charcoal	Continuous furnace wood-drying	7.5 TPH	0.04	0.06	1.06
		7.5 TPH	1.21	1.70	0.40
Formaldehyde	Absorber vent	0.100 MTPY	1.48	2.08	0.18
		0.040 MTPY	2.67	3.73	0.20
Dimethylterephthalate	Scrubber	0.120 MTPY	0.52	0.73	0.44
		0.030 MTPY	0.44	0.62	0.27
Phthalic anhydride	Condensors	0.065 MTPY	0.63	0.88	0.48
		0.047 MTPY	0.56	0.78	0.44
Iron and steel	Coke oven charging	0.35 MTPY	0.82	1.14	0.24
		0.72 MTPY	1.24	1.73	0.22
Cyclohexanol	Product recovery vent	0.110 MTPY	7.13	9.98	0.27
		0.025 MTPY	3.99	5.58	0.17
Process heater	Gas-fired	150 10^6 Btuh	0.000	0.000	0.62
		50 10^6 Btuh	0.000	0.000	0.41
Ethylene dichloride	Fractionation vent	0.440 MTPY	3.31	4.63	0.37
Internal combustion	Diesel	1,200 HP	0.03	0.04	0.20
	Dual fuel	4,300 HP	0.08	0.12	0.31
	Natural gas	1,500 HP	0.004	0.01	0.22
		4,400 HP	0.01	0.01	0.48

To conduct a second screen, the PTMAX program was modified to calculate each source's effective plume rise (a measure of the dispersion characteristics of emissions) and to determine, for that plume rise, the CO emission rate that would yield a carbon monoxide ambient concentration of 0.5 ppm (under worst case meteorological conditions, i.e., wind speed of 2.0 m/s and stability class A). The modified PTMAX program was applied to the source data in the National Emission Data System (NEDS) point source subfile. Therefore, based on actual rather than "model" stack and emission characteristics, this PTMAX screen produced a subfile comprised of those point sources in NEDS which would produce ambient concentrations above 0.5 ppm; the 0.5 ppm concentration was selected as a conservative threshold of potential to cause ambient violations even under the most stringent alternative.

The resulting subfile included over 700 point sources. Additional source categories beyond those eight previously listed then were identified for control cost development based on 1) their expected magnitude of air quality impact, or 2) the number of sources within that category contained in the subfile.

Data validity checks were performed on a number of sources in the subfile. Emission rates (AP-42 uncontrolled vs. NEDS) and their consistency with operating and stack data were verified. After correction for apparent data errors, six additional process categories were identified for cost development; they were:

- Carbon black
- Iron sintering
- Electric arc furnace
- Gray iron cupola
- Conical wood incinerator
- Municipal incinerator.

B.1.4 Source Category Control Cost Development

For the 14 potentially significant processes screened in the preceding two steps, capital and annualized costs were obtained for two typical operating rates within each process category.* The technology selection was based on currently demonstrated control equipment; no experimental technology was considered (PEDCo, 1979a).

As indicated, costs (capital and annualized) were developed for two process sizes which are deemed reflective of the range of typical operation. The two cost estimates were used to construct an exponential equation for each process category which, upon inputting a source's specific annual capacity or production level, would produce the costs of a unit of appropriate size. The log-log curve represented by the equation is used to capture economies or diseconomies of scale inherent in the two size-specific point estimates.

In three cases, a single process size was indicated, hence the control costs for that size were assumed to be linear per unit of production (a uniform $/ton of product). For one process, the conical wood incinerator, the costs of control do not vary by size; therefore, the capital and annualized costs are level.

B.2 TOTAL COST METHODOLOGY

B.2.1 Evaluation of Ambient Impact

In order to determine the costs incurred by each alternative standard, the evaluation of the extent to which existing sources violate mandated concentration levels constitutes the first step. PTMAX was applied to the 700 point sources in the NEDS subfile. For the purposes of costing, the meteorological assumptions were stability class B and a wind speed of 2.5 m/sec, as it was felt that these represent more realistic atmospheric conditions and would produce consistently valid results from PTMAX (i.e., plume rises of less than 500 m).*

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* There are several exceptions where only one size was costed. See PEDCo, 1979b.

A background level of 2 ppm CO was included to reflect the probable concentration of area sources at points of maximum point source impacts. The 2 ppm background was assumed sufficient since point sources generally are removed from highways and other major transportation routes where high CO concentrations from area sources occur. No natural background was considered.

The background level, assumed equal for all point sources, can be considered either to increase the point's impacts on air quality (since the source's concentration is no longer considered truly in isolation) or to reduce effectively, by 2 ppm, each alternative ambient standard. For ease of analysis, the background was incorporated in the latter manner.

Each point source's maximum concentration was calculated using PTMAX and revised atmospheric conditions. The concentrations of multiple points at any facility were aggregated to the plant level, thereby assuming that the plant impact equals the sum of the process maximum impacts. This procedure will overestimate the actual plant impact because it assumes that these maxima occur at the same location. No interaction among plants was assumed; the source file produced under the revised meteorological assumptions contained 275 sources which did not exhibit a significant degree of co-location. It was believed that the level of source interaction would not be of a magnitude that would jeopardize the conclusions reached using PTMAX.

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* PTMAX will calculate ambient concentrations for plume rises above 500 m, but will identify the prediction as invalid.

The calculated plant concentration level then was compared to each alternative CO standard adjusted for background. (The plant total was corrected by the 0.7 persistence factor for comparison with eight-hour standards.) It should be noted that the form of the standard, whether statistical or second-high, was not considered. The calculated impact was used directly. The adjustment to a statistical form or calculation of a second high would require the variation of the meteorological conditions to produce the variability exhibited by monitored data. Such a data manipulation was beyond the scope of this analysis. The result is, as with the sum of process maxima, a bias upward in the forecasted impacts.

B.2.2 Calculation of Required Emission Reductions

Emission reductions required under each alternative standard were calculated assuming proportionality between reduction in emissions and air quality levels; a linear rollback equation was used:

$$\text{\% Emission Reduction} = \frac{\text{Plant Concentration} - (\text{Ambient Standard} - \text{Background})}{\text{Plant Concentration}}$$

If the plant impact does not violate any standard, the equation produces a negative result and no reductions are calculated.

B.2.3 Least-Cost Strategy Determination

The required reduction in emissions refers to plant totals. Since many plants constitute the combined impact of multiple emission points, emission reductions can be produced by a variety of control option combinations. For this analysis, the required emission reductions were obtained through an option or combination of options which resulted in the lowest total annualized cost for the plant, thus accounting for initial capital outlays.

Each plant's control options were calculated and ranked by cost effectiveness, that is, lowest to highest cost per ton of CO removed. All options needed to produce the tonnage emission reduction are applied to each source in order of decreasing cost effectiveness; that is, the lowest $/ton removed controls and sources are selected first.

Because of the discrete nature of control technology, it is possible that a plant might employ a less cost-effective means of control simply by choosing control options which have the lowest average annualized cost per unit of reduction. For example, a facility consists of two points: point A emits 100 tons per year and point B emits 200 tons per year. Assume that the required emission reduction is 50 percent for the plant, or 150 tons; point A can be controlled at 90 percent efficiency for $1/ton; point B may be controlled at 75 percent efficiency for $2/ton. By a cost-effective ranking, the choice would be to control point A first; however, since point A only provides 90 tons of reduction, point B also must be controlled. As a result, the plant expends $390 in annualized cost for 240 tons of reduction. However, if only point B were controlled, it could achieve the entire 150 ton reduction at a total annualized cost of $300. A verification procedure was used, therefore, to ensure lowest total annual cost, in this example, to check whether the controls on point A were necessary;* since they were not, the least-cost algorithm would control point B only. The results of the costing procedure are presented in Section 3.5.

B.3 BENEFITS FROM STEAM CREDITS

The burning of carbon monoxide is an exothermic reaction. If the exhaust stream of CO from a process is sufficiently dense, the energy released from burning the gas may be used in one of two manners. The energy from combusted CO can be used to heat the continuing stream of process gas before combustion. This procedure, called primary heat recovery and illustrated in Figure B-1, can reduce the amount of supplemental fuel needed to burn the process gas. Secondary heat recovery, as illustrated in Figure B-2, generates steam from the heat released from the combusted CO. This steam may be used in certain processes within the plants thereby reducing costs of burning fossil fuels to produce needed steam.

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* The need for controls on point B are not reverified, however, since point B's controls obviously were necessary to achieve the total reduction.

The use of secondary heat recovery increases capital cost, however. For example, using incineration with primary heat recovery to control CO from an iron ore sinter plant producing 1.19 x 10^6 tons per year incurs a capital cost of $3.4 million. With the addition of secondary heat recovery the capital cost becomes $3.86 million, an increase of over 13 percent.

However, the secondary heat recovery provides enough annual steam credit* to more than offset the capital cost increase; using the same sinter plant, control with primary heat recovery operates at an annual cost of $3.5 million. The addition of secondary heat recovery provides enough steam to provide a net annual savings of $3.3 million (PEDCo, 1979b).

It should be noted that not all sources can use secondary heat recovery. Its application will depend on the quantity/concentration of CO in the off-stream and the degree of steam-heating requirement (i.e., if supplemental fuel for combustion is necessary). Moreover, it is possible that certain processes would not be amenable to secondary heat recovery because no steam is required. In this event, credits for steam are not valuable since steam normally is not purchased or produced. As a result, firms, in choosing to minimize expenditures, likely would select primary recovery since, without credits, secondary recovery is more expensive.

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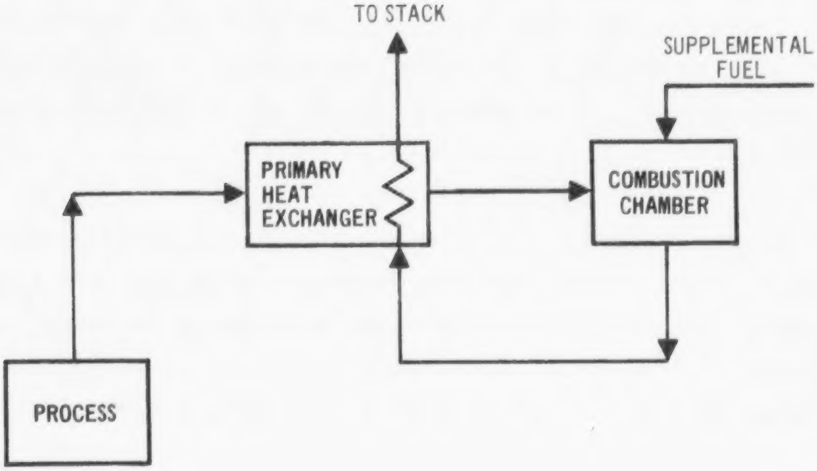
* The steam credit is a product of calculating the cost of steam (based on fossil fuel combustion) times the quantity of steam produced by a CO boiler.

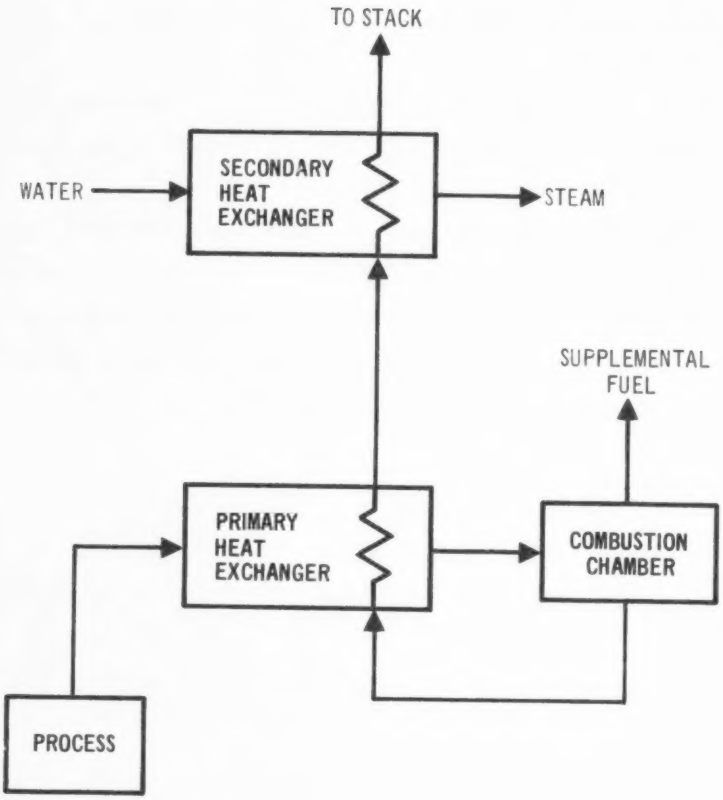
FIGURE B-1

SCHEMATIC OF INCINERATION SYSTEM WITH PRIMARY HEAT RECOVERY


TO STACK
SUPPLEMENTAL FUEL
PRIMARY HEAT EXCHANGER
COMBUSTION CHAMBER
PROCESS

Source: PEDCO Environmental, Inc. June 1979. "Carbon Monoxide Control Costs for Selected Processes." Prepared for U.S. EPA.

FIGURE B–2
SCHEMATIC OF INCINERATION SYSTEM WITH PRIMARY AND SECONDARY HEAT RECOVERY


TO STACK
WATER
SECONDARY HEAT EXCHANGER
STEAM
SUPPLEMENTAL FUEL
PRIMARY HEAT EXCHANGER
COMBUSTION CHAMBER
PROCESS

Source: PEDCO Environmental, Inc. June 1979. "Carbon Monoxide Control Costs for Selected Processes." Prepared for U.S. EPA.

The application of secondary heat recovery by any process was based on engineering judgment concerning the off-stream characteristics and the utility of the steam output. Since secondary recovery produces a negative cost, it always is selected by the costing algorithm for those processes where it is an option. The possibility that actual units may not be appropriate for secondary recovery, as opposed to the "model" processes costed, implies that the credits calculated may be optimistic.

In the event that, say, half the credits were not technologically or economically feasible, the annualized costs presented in Section 4 are understated while the capital costs are overstated. Because the capital cost picture changes in the absence of steam utility, it is not necessarily the case that annual costs merely are halved. Rather, on a case-specific basis, a determination would be needed regarding the advantage of secondary versus primary recovery relative to the degree of steam needed. For the purpose of this analysis, 100 percent credit was assumed.

B.4 CO SOURCE GROWTH

Inclusion of growth in CO emission sources would serve two purposes:

- To add costs automatically incurred due to New Source Performance Standards (NSPS) to the baseline costs
- To identify the level and cost of new source control motivated by the ambient air quality standard for CO.

Towards these ends, an evaluation was made of the extent to which new source controls are mandated by air quality limitations for CO.

At present, two process categories have NSPS promulgated for CO: the catalytic cracker (petroleum refining) and the electric submerged arc furnace (ferroalloy production). The control technology for the catalytic cracker is a CO boiler. For a new source, this type of control would be used in the absence of the standard because its operation provides a net credit due to steam generation and, thus, an economic benefit. Since economics, rather than emissions control, constitutes the prime motive for CO recovery, the costs are not attributed to NSPS. Moreover, even uncontrolled FCCU have negligible ambient impact (refer to Table B-2); it is improbable that any of the alternative standards would motivate more stringent control, or significant costs.

Ferroalloy furnaces do not employ end-of-pipe controls specifically for CO reduction. In open furnaces, the CO combusts as part of the process while, in semi-enclosed furnaces, flaring the exhaust gas to reduce visible emissions also reduces CO. For this reason, the NSPS for this process was not considered to incur cost. Further, since the NEDS screen did not capture any ferroalloy furnace, it appears logical to conclude that this process does not constitute a significant source of ambient impact. Accordingly, additional control or costs under any alternative standard are not likely.

Beyond NSPS, other processes and industries were examined. Since incorporation of growth would be made, analytically, on a model source basis, only five processes would exhibit potential impacts (see Table B-2) at uncontrolled levels, thus motivating controls and incurring costs.

However, an examination of the typical control measures for these processes revealed either of two practices:

- Use of secondary heat recovery (e.g., CO boilers) to capture CO as a fuel, or
- Use of incineration of hydrocarbons to reduce adequately CO emissions.

In either case, it would be inappropriate to assign the total costs or credits associated with these types of measures to the carbon monoxide standard. Moreover, because the total costs incurred by existing point sources are relatively small,* the significance of a growth increment likely would be small as well. The analysis indicated, therefore, that the incorporation of growth would not have noticeable effects on the magnitude of the costs estimated for attaining CO standards. For this reason, especially, the cost analysis is confined to the existing base of stationary point sources.

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* Vis-a-vis mobile source total costs.

REFERENCES FOR APPENDIX B

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